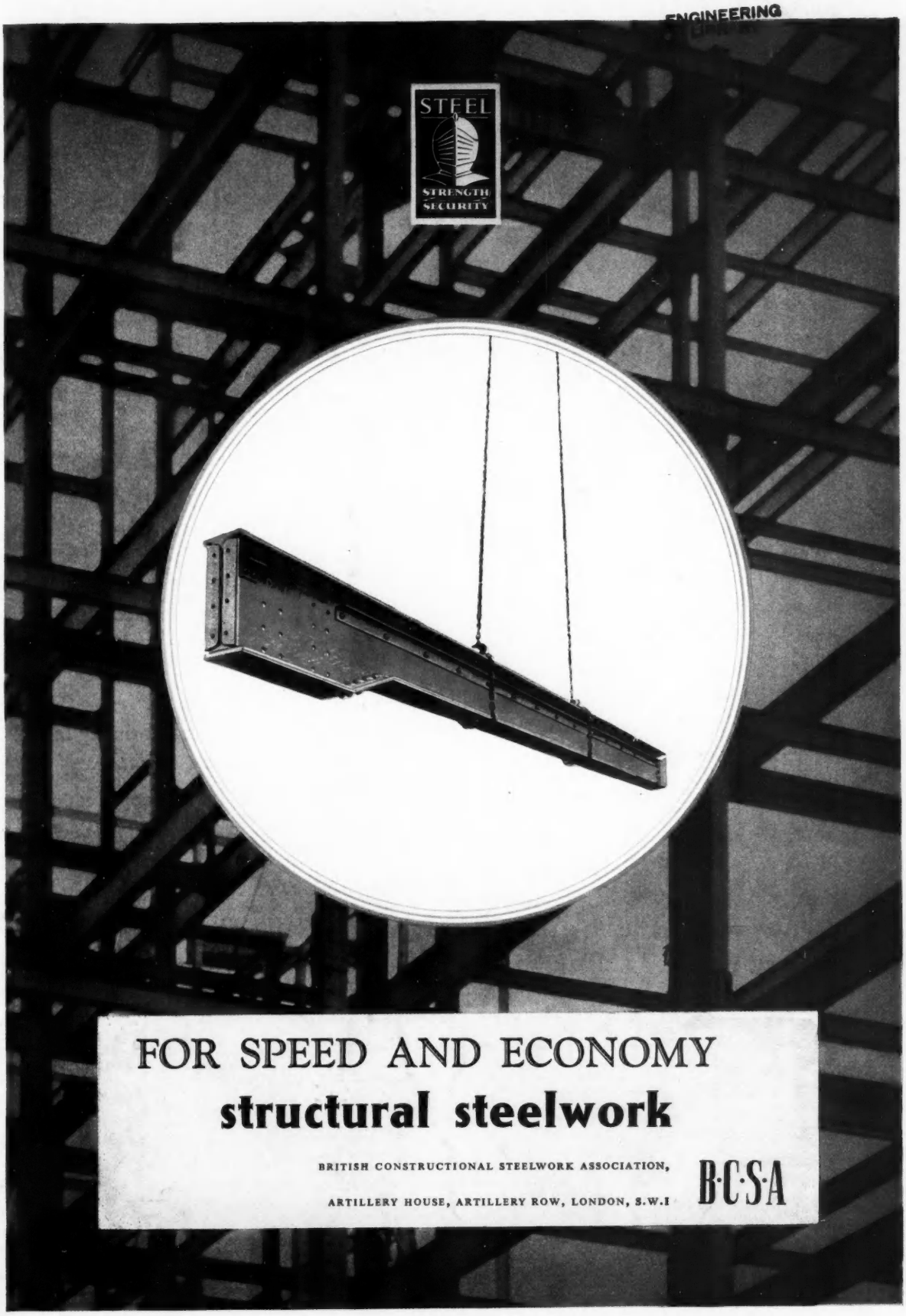
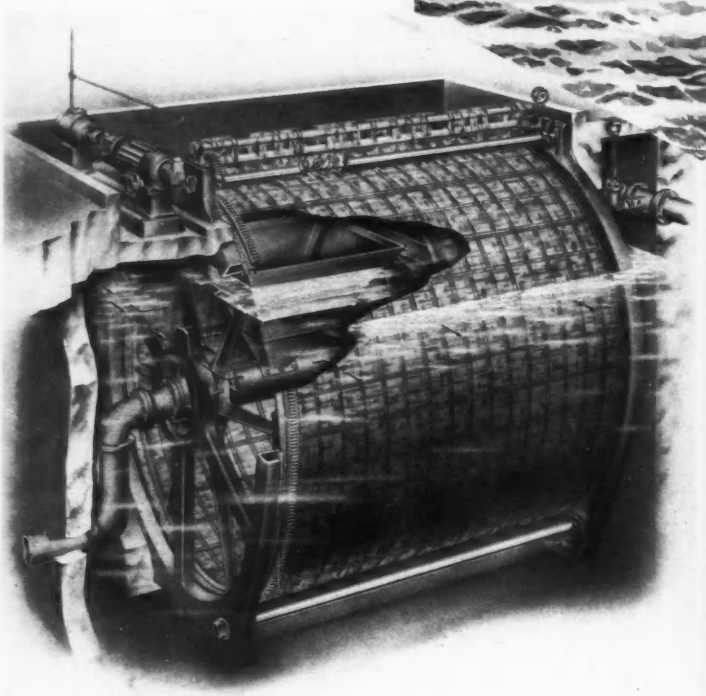
The Engineer

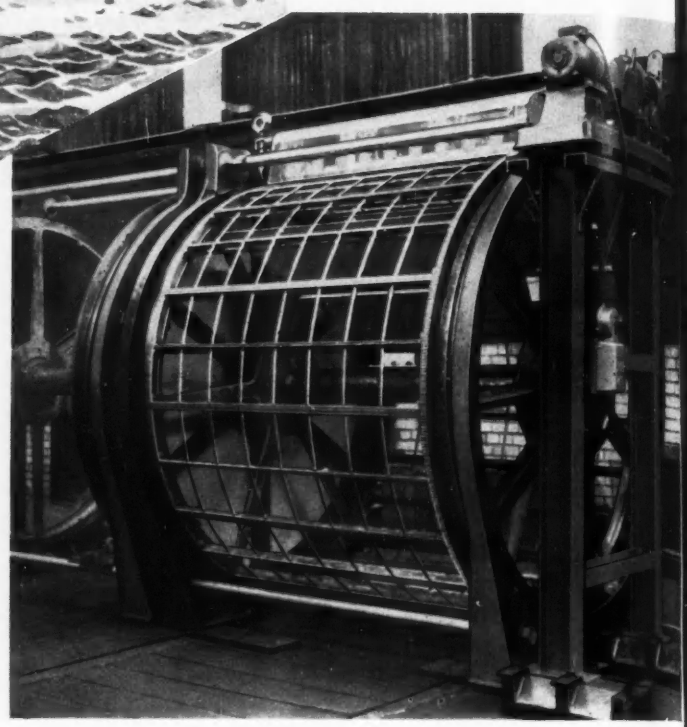
JUNE 3, 1955 — 28, ESSEX ST., STRAND, LONDON, W.C.2 — TWO SHILLINGS

UNIVERSITY OF MICHIGAN
JUL 7 1955
ENGINEERING



Micro-Straining





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THE ENGINEER

JUNE 3, 1955

Iron and Steel Board's Report

THE Iron and Steel Board has published its first annual report, which covers the period from July 13, 1953, when the Board began to operate, till December 31, 1954. The report naturally contains a great deal of statistical matter about the British iron and steel industry, which has already been published in our columns. In its references to steel production and supplies, the report says that the course of demand for steel last year showed two distinct phases. During the first five months of the year, the order book for steel products was falling continuously, but in the second part of the year the trend was reversed and the level of outstanding orders rose each month. The report goes on to mention that in the first six months of 1954 there was no general shortage of steel supplies, but in the second half of the year "attitudes changed." This, it is suggested, was in part due to domestic policies, particularly the added encouragement given to capital investment, to the progressive elimination of building licensing, and to the expansion of demand for durable consumer goods facilitated by the removal of restrictions on hire purchase and to a small extent by reduction of purchase tax. Overseas, too, the outlook changed. In the third quarter orders on Continental steel works began to increase, and in October the decline in United States steel production was reversed. As to the outlook for 1955, the report says that "the possibility of exceeding a production of 19,500,000 tons and of obtaining the necessary raw materials to do so will be kept under constant review." Imports purchased centrally for use in the finishing sections of the industry are expected to be the equivalent of 600,000 tons. The total which consumers themselves will bring in cannot accurately be forecast, but is expected to be about 750,000 ingot tons. The major imports are likely to be sheet and tinplate, for which products the recent rise in demand has been most marked. The report estimates that total imports of all forms of steel this year will be approximately 1,350,000 ingot tons, and it says that the total supply of steel may thus be 1,800,000 tons more than last year. But the report was issued, of course, before the railway strike started. Transport difficulties which that has caused must undoubtedly affect, among many other things, the iron and steel output of this country.

Joint Metallurgical Societies' Meeting

A MEETING of representatives from the leading metallurgical societies in the United Kingdom, the U.S.A., Belgium, France, Germany and Sweden, opened in London on Wednesday afternoon. The organisation for that part of the meeting which is being held in this country has been the responsibility of the Iron and Steel Institute and the Institute of Metals. When the sessions in this country end next Tuesday, the delegates will proceed to the Continent, where the meeting will continue in Germany, Belgium and France until June 18th. The objects of this joint meeting are to establish personal contacts between experts in Canada and the U.S.A. and in Europe, to provide opportunities for scientific and technical discussion, to enable visitors from Canada and the U.S.A. to see something of Europe's metallurgical industries, and to foster better understanding and co-operation among all those concerned. At the opening plenary session of the meeting on Wednesday, the delegates were welcomed by the presidents of the Iron and Steel Institute and the Institute of Metals, and the Iron and Steel Institute's Bessemer gold medal for 1955 was presented to Professor John Chipman, of the Massachusetts Institute of Technology. Thereafter, a lecture entitled "X-Ray Analysis and the Structure of Metals" was delivered by Sir Lawrence Bragg, F.R.S. Technical discussions, by groups of the delegates, started yesterday. The discussions cover many metallurgical matters, including iron and steel making; mechanical working and heat-treatment, both ferrous and non-ferrous; the refining and fabrication of non-ferrous metals; metallurgical education and training in industry, and metallurgical research. A series of tours to various centres of metallurgical industry in this country has been arranged as part of the programme.

Anglo-German Industrial Transport Problems

IT is announced by the Association of British Chambers of Commerce that a group of experts on industrial transport will visit Germany this month to discuss industrial transport problems with their counterparts in Germany. The main subject of discussion will be concerned with rail and road competition and railway charges. The British delegation will be broadly representative of industry and will be made up of members from all parts of the country. While in Germany a tour will be made of the German Federal Railways and visits will be paid to freight-handling depots, road haulage establishments, and to industrial undertakings operating their own transport systems. A particular study will be made of the charging system of the German State Railway with special reference to the use of charges as a weapon of competition with other forms of transport. Attention will also be given to the problem of road/rail co-ordination, its economics and the practical issues involved, such as physical handling and the attitude of labour. The delegation will be led by Mr. T. H. Summerson, a vice-president of the Association and chairman of its home affairs and transport division. Its number will include Mr. E. W. Arkle, the commercial superintendent to the Midland Area of British Railways, who will be available to give expert advice on operating and commercial matters.

Institution of Electrical Engineers

THE annual report of the Institution of Electrical Engineers for the year ended March 31st was presented at the annual general meeting of the Institution on May 19th last. The report shows that, although the rate of growth of membership recorded in recent years has been maintained, it is still insufficient to meet the national need for adequate numbers of professionally qualified electrical engineers. On April 1st last the total membership was 39,298 (an increase of 802 during the year), of whom 31,148 were corporate members or graduates: for the first time the total number of corporate members exceeded 20,000. During the year the number of graduates increased by 436 to a total of 11,153. In the report the council expresses concern at the fall in the number of applications for student membership, which is reflected by the fact that the number of student members on the register decreased from 5423 in 1954 to 4993 in 1955. The report of a special committee set up to study this decline is now being considered. Details of the Institution's activities and technical investigations are given in the report and reference is made to joint activities with other bodies. A separate section of the report deals with education. It refers to some of the measures adopted to stimulate recruitment to the electrical engineering profession. For example, an analysis is being carried out of the number of places available in the electrical engineering departments of the universities and the extent to which they are being filled; a well-illustrated careers booklet is being prepared; and a film, "The Inquiring Mind," is being produced for showing to senior boys at public and grammar schools to acquaint them of the opportunities offered by a career in electrical engineering. On the subject of technological education the I.E.E. report shows the existence of major differences between the Joint Advisory Committee on Education of the three Engineering Institutions and the National Advisory Council on Education for Industry and Commerce. The main divergences are concerned with the insistence by the Institutions on three main points. First, that the present limited teaching resources should at the outset be concentrated in the small number of colleges which maintain the necessary standards for the new courses and awards and should be recognised accordingly. Secondly, that the control of conditions leading to the new educational award should be in the hands of those who were professionally qualified to adjudicate. Thirdly, that the award in engineering should have a title which was readily distinguishable from that used for secondary technologies, to avoid the risk of confusing the public by the existence of varying academic standards. The report goes on to observe that the Minister of Education received representatives of the Institutions in February last and that "in spite of the unanimity of view expressed by the professional, scientific and technological Institutions, he (the Minister) appears, at present, to find the views of the National Advisory Council for Industry and Commerce more acceptable."

Aluminium Centenary Exhibition

THIS year marks the completion of the first century of aluminium as a commercially produced metal and to celebrate the centenary of the first production of aluminium in this country an exhibition is being held in the Royal Festival Hall, London. The exhibition, which has been arranged by the Aluminium Development Association, opened on Wednesday, June 1st, and will remain open until Friday, June 10th. It presents a historical account, a survey of current activities and future expansion and, broadly, shows the overall pattern of technical development. There are twelve main sections illustrating the wide application of aluminium and its alloys in many industrial fields, and during the exhibition a series of six discussions has been arranged. These discussions relate to particular branches of engineering, namely, electrical, building and structural engineering, road transport, railways, marine applications and packaging, and each is preceded by the reading of a short paper. Most of the exhibits are in the Festival Hall, but there are many large items to be seen outside. These include small craft and marine fittings, examples of structural applications, road and rail transport units, and farm buildings and equipment. Inside the hall there is an introductory display of raw materials, panels illustrating the properties of aluminium, followed by sections dealing with aircraft, road transport, consumer goods, marine applications and developments, rail transport units and components, the packaging industry, and the use of aluminium for building purposes. Further sections are concerned with the advances made in the use of the metal in structural, chemical, general and electrical engineering, and in the agricultural and food industries. The historical display indicates the principal stages in the development of the aluminium industry, while in another foyer are examples of various items of research work, together with sketches illustrative of the employment of aluminium in the future.

Vertical Boiler Locomotives

By R. A. S. ABBOTT*

No. II—(*Continued from page 728, May 27th*)

The study of the history of the industrial locomotive is a fascinating subject, quite outside the scope of ordinary railway and locomotive literature, and one which offers a wide field for research. For many years the writer has made the industrial and light locomotives with vertical boilers his special interest, and as no previous history of this type of locomotive has ever been published it is hoped that this excursion into a little explored by-way of locomotive engineering will prove welcome to both the engineer and historian.

Butterley Locomotives

THE famous Butterley Company was established at Ripley in Derbyshire in 1790, and is known throughout the world today as a builder of bridges and railway rolling stock, but was formerly well known for the manufacture of stationary and marine steam engines, as well as being the owner of collieries. To work its extensive railway systems not only at Ripley, but also at Codnor Park Works, Nottingham, and the outlying collieries, the Butterley company constructed in its own workshops at Ripley at least twenty-six locomotives. Most of these were four and six-coupled saddle tanks, with outside cylinders, but six of the very early ones were four-wheeled, with vertical boilers. They had a geared drive with a ratio of 3 to 1, with a cylinder diameter of only 4in. Only one of them is now traceable, No. 23 of 1870, but no further details are available owing to the destruction of records at the works some years ago.

Sara and Burgess

At Penryn, near Falmouth, a foundry was started in 1857 by Nicholas Sara, at one time a foreman at the famous Perran Foundry. In 1887 the owners were his son, E. B. Sara, and John Burgess, also an old Perran man. This firm of Sara and Burgess was responsible for building at least four vertical boiler locomotives, although the dates of construction are not known. Three of them were used by the Falmouth Docks and Engineering Co., and one worked at Par Harbour. Of these, the Falmouth ones were originally built as broad gauge and later converted, while the one for Par belonged to a much later period and was constructed about 1910–12.

The vertical cylinders, 7in diameter by 12in stroke, drove the 3ft diameter coupled wheels by spur gearing to the front axle. The boiler was 8ft high and 3ft diameter. Mounted on half-elliptic springs, these locomotives had the water tank between the frames with the coal bunker at the rear. One of the Falmouth locomotives is illustrated in *The Locomotive* for 1899, page 52.

Shanks

Alexander Shanks and Son, Ltd., Dens Iron Works, Arbroath, in addition to building the normal form of contractors' four-coupled, outside cylinder, saddle-tank locomotive, also introduced between 1870 and 1880 a series of vertical boiler locomotives. These locomotives, illustrated by Fig. 6, which is from a woodcut in an early catalogue, had cross tubes in the boiler and were geared in the ratio of 3 to 1, being made in several sizes suitable for gauges of 2ft 11in upwards. Messrs. Shanks are unable to supply further dimensions, but the details of the design are clearly shown in the illustration.

* Member, Newcomen Society; Member, Industrial Locomotive Society.

Hunslet

During the year 1871, the Hunslet Engine Company, Ltd., Jack Lane, Leeds, completed the first vertical boiler locomotive to be constructed by that firm. It carried works order No. 52 and was a 2–2–0 side-tank inspection locomotive for the Oudh and Rohilkund Railway in India. Built to the 5ft 6in gauge, it had two outside cylinders, 5½in diameter, with a stroke of 12in, while the driving wheels had a diameter of 3ft 9in, the carrying wheels being 2ft in diameter. The position of the boiler was at the back, just in front of the driver's footplate. Although the original general arrangement drawing of this locomotive still exists in a very torn condition, it is regretted that an outline diagram cannot be reproduced here.

After a gap of twenty years, the Hunslet Engine Company supplied a very small vertical boiler locomotive for a 2ft 2¾in gauge line in Spain. This was works No. 551 of 1891 and is illustrated by Fig. 7. The leading dimensions were as follow:—Cylinders, 4in diameter with a 6in stroke; wheels, 1ft 6in diameter; wheelbase, 2ft 8in; overall length, 6ft 5¼in; total height, 7ft. The boiler contained thirty-seven tubes of 1½in diameter with a length between tube plates of 2ft 3½in, while the outside diameter of the boiler was 1ft 10in and that of the firebox 1ft 5¼in. The heating surface was made up of 21·5 square feet of tube surface and 8·5 square feet in the firebox. The grate area was 1·5 square feet. The water capacity was 80 gallons and the bunkers held 8 cubic feet of fuel. It should be noticed that this locomotive was not geared, had outside frames and cranks for the coupling-rods and was unsprung.

A third vertical boiler locomotive appeared in 1893 (works No. 600) and was for a 3ft gauge line near Novorossisk (Fig. 8). This locomotive had the same size cylinders, wheels and boiler as the one built in 1891, but the wheelbase was 3ft, overall length 7ft 11in, total height 8ft 2in, and it had an overall closed-in cab. The water tank capacity was 80 gallons, and the fuel bunkers held 11 cubic feet. The locomotive was also unsprung and not geared, but had inside frames. The weight in working order was 2 tons 14 cwt 2 qr.

Head, Wrightson

Messrs. Head, Wrightson and Co., Teesdale Ironworks, Stockton-on-Tees, produced

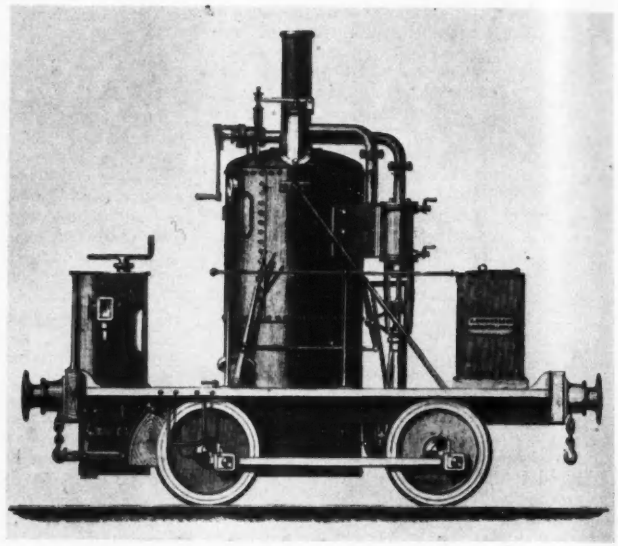


Fig. 6—Locomotive by A. Shanks and Son, Ltd., built during the period 1870-1880

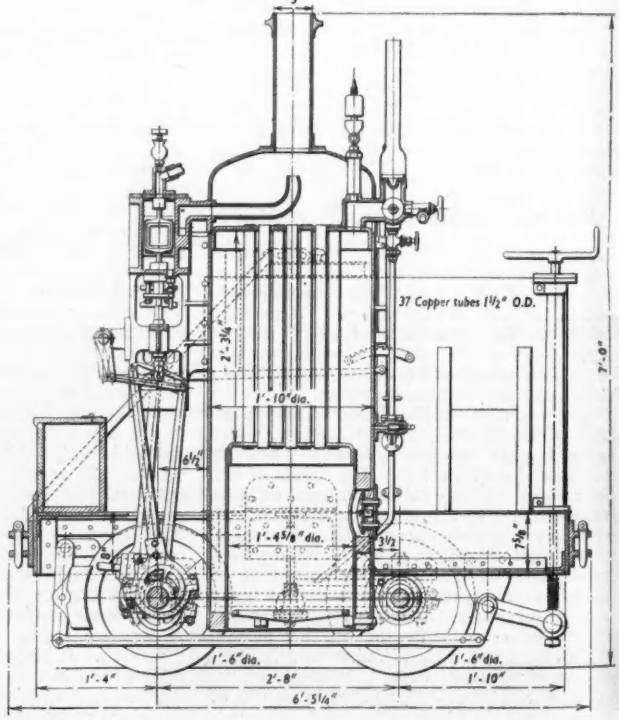


Fig. 7—Locomotive by Hunslet Engine Company, Ltd., 1891, for Spain

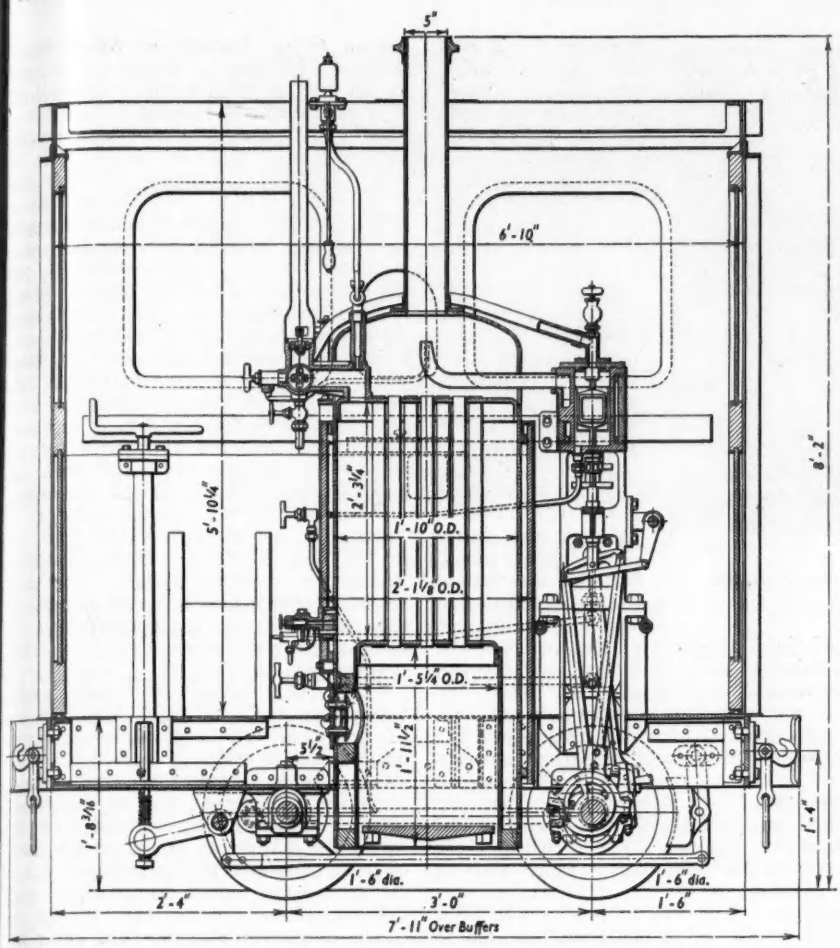


Fig. 8—Locomotive by Hunslet Engine Company, 1893, for Russia

vertical boiler locomotives during the period 1870–1880, and the majority are presumed to have gone to local ironworks and collieries in Durham, but at least one went to Surrey, and the yard locomotive at the Hannoversche Maschienenfabrik (Hanomag), Hanover, was at one time a Head, Wrightson vertical boiler engine. Two distinct designs were built, one with vertical engine and geared drive, while the other had direct drive by normal outside sloping cylinders. The geared engine had two cylinders complete with regulator bolted direct on to the boiler, which was carried on a cast iron frame, while the forked-ended connecting-rods operated on to a crankshaft whose main bearings were held in another casting bolted to the bottom of the firebox. No eccentrics were fitted, the link motion being operated by two small cranks offset from each main crank on either side.

The reversing lever was on the right-hand side. A locomotive of this design is still at work in Surrey, having been delivered to the Dorking Greystone Lime Company at Betchworth in 1871, and the following dimensions applied to this locomotive when new :—Cylinders, 6in diameter by 12in stroke ; gear ratio, 3 to 1 ; the wheel centres were of cast iron and 2ft 4in diameter over tread, set on a wheelbase of 5ft 6in. The original boiler, with conical topped smokebox, was 3ft 6in diameter, with a firebox 2ft 10in high, and contained thirty-six wrought iron tubes 2in diameter. A photograph of this locomotive in original condition appeared in *The Locomotive*, 1931, page 303.

Another locomotive of this pattern was supplied to the Londonderry Estates Co. Durham, in 1870, works No. 21, and it is still at work as Seaham Harbour Dock Company, No. 16 (Fig. 9). This retains the conical smokebox and the present dimensions are : cylinders, 6¼in diameter by 14in stroke ; gear ratio 2 to 1 ; overall diameter of wheels, 2ft 6½in diameter ; wheelbase 5ft 6in ; outside diameter of boiler, 3ft 6in ; height of boiler, 6ft 6½in ; number of tubes, 70, with a diameter of 2in ; length of tubes, 3ft 9½in ; diameter of grate, 2ft 10½in ; working pressure, 100 lb per square inch ; overall length, 11ft 7in ; weight in working order, 10 tons.

The other design, with direct drive, is shown in Fig. 10, and this particular locomotive was also supplied to the Londonderry Estates in 1873, Works No. 33, and is now working as Seaham Harbour Dock Company No. 17. The photograph is sufficiently clear to show all the principal features, and the present dimensions are : cylinders 9in diameter by 14in stroke, with reversing lever on right-hand side ; diameter of wheels 2ft 5½in ; wheelbase 5ft 4in, outside diameter of boiler 3ft 4in, with a height of 7ft 4in ; number of tubes ninety-nine, of 1½in diameter ; length of tubes 3ft 11½in ; diameter of grate 2ft 9½in ; working pressure 120 lb per square inch, overall length 13ft 6in. The weight is slightly more than 10 tons.

It is unfortunate that so little is known about such an interesting series of locomotives, for although the firm of Head, Wrightson and Co., is still flourishing, it no longer possesses any records of locomotive work. Neither is it possible to estimate the number of vertical boiler locomotives built from the Works Numbers that are known, because the firm also built a number of normal four-wheeled outside-cylindered saddle tank locomotives from 1871 onwards.

Cochranes

At the North Ormsby Ironworks of Cochrane, Grove and Co., Middlesbrough (now Cochranes (Middlesbrough) Foundry, Ltd.), there were until the middle 1930s a series of nine vertical boiler locomotives for use on the private lines in and about the works. These locomotives, Fig. 11, have always been regarded as having been built at the North Ormsby Works, and this was confirmed recently in a communication from the firm which stated that they were unable to say when these locomotives were constructed or to supply dimensions as all drawings relating to them were destroyed some years ago. From another source, however, it seems clear that these locomotives were built during the 1860–1880 period, being completed at intervals as required. The photograph reproduced overleaf was taken in July, 1933, when this particular locomo-

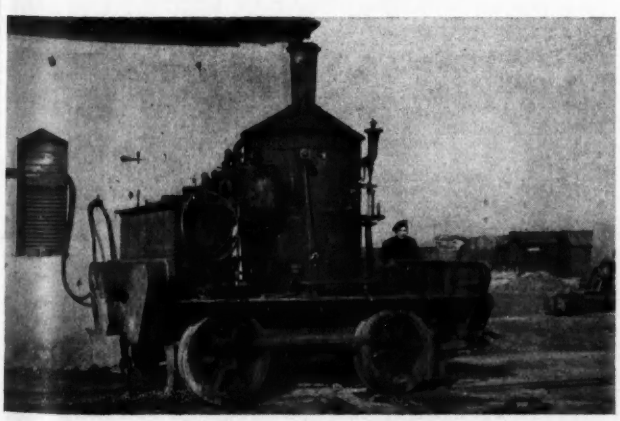


Fig. 9—Head, Wrightson locomotive, geared drive, built 1870, for the Londonderry Estates Company, Durham

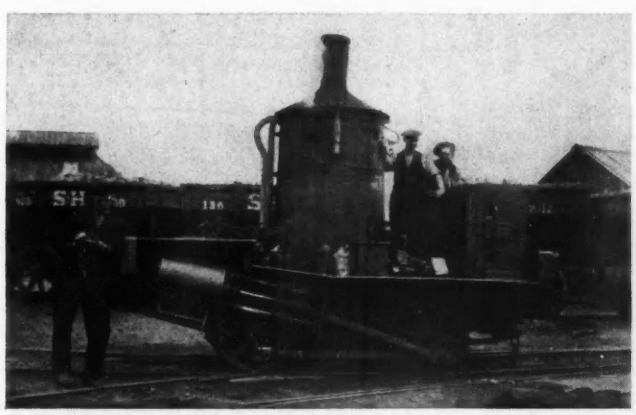


Fig. 10—Head, Wrightson locomotive, with direct drive, built 1873, for the Londonderry Estates Company, Durham

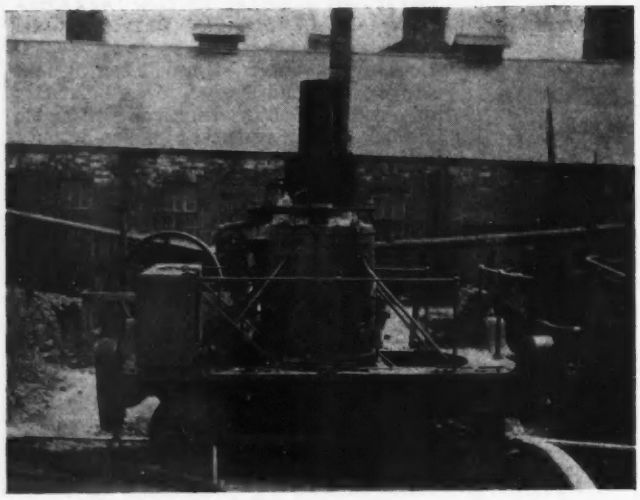


Fig. 11—Locomotive by Cochrane, Grove and Co., built during the period 1860-1880

tive was working at the Linthorpe-Dinsdale Smelting Company, Ltd., Dinsdale.

Appleby

Messrs. Appleby Bros., East Greenwich, are known to have built small contractors' locomotives during the 1870s (see *Engineering* for January 20, 1871, page 43), and from certain references in trade journals about this period there is reason to believe that vertical boiler locomotives were among their productions.

"Mona" from Anglesey

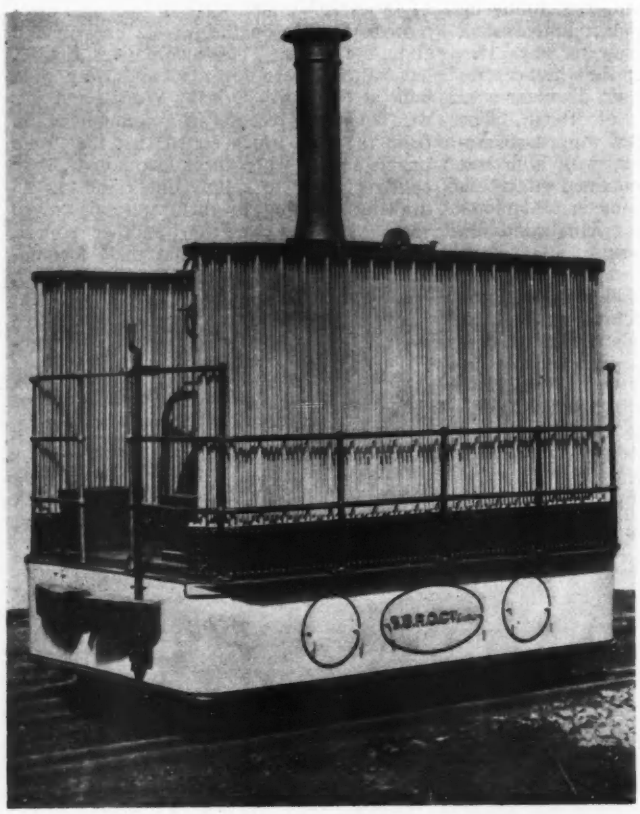
One does not usually regard the agricultural island of Anglesey as a district where locomotives have been built, but there is evidence extant which makes it reasonable to assume that at least two vertical boiler locomotives were constructed by Owen Hughes, Valley Foundry, Holyhead. Before the amalgamation of the two granite quarrying companies at Penmaenmawr with the Welsh Granite Company, of Trevor, to form the present Penmaenmawr and Welsh Granite Company, the Penmaenmawr quarries were worked by Darbishires, Ltd., at the Craiglwyd quarries (the eastern section), and Brundrit and Co., Ltd., on the actual Penmaenmawr mountain itself (the western section). The first locomotive to be used in the quarries was ordered by Brundrit and Co., Ltd., and was supplied by Hughes; he made the boiler and frame and purchased the cylinders and motion from Dublin. This locomotive, named the "Mona," did not give satisfaction and had been in use only a short while when an order was placed with de Winton and Co., of Caernarvon, for one of their vertical boiler locomotives. This arrived in 1878 and some kind of a bargain was made with de Winton's to take the "Mona" in part payment. This was agreed to and after being rebuilt at Caernarvon it was sold to the company operating the limestone quarry on the Little Orme.

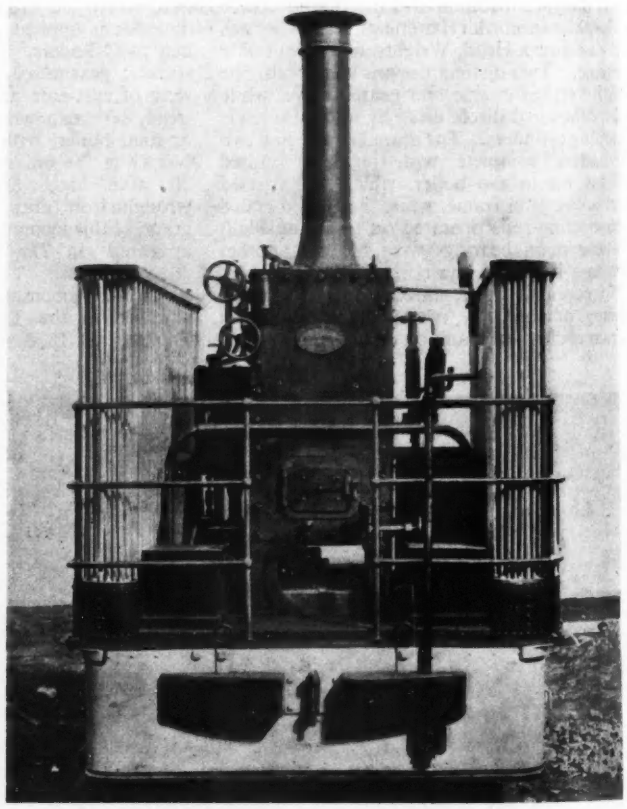
The other locomotive attributed to Hughes is referred to by C. E. Lee in his book *Narrow Gauge Railways of North Wales*, where he mentions a vertical boiler locomotive used at Penrhyn Quarry in the early days and named "Fronllwyd" (ex-"Coctinor") and reputed to have been built at Valley.

Yorkshire Engines

The Yorkshire Engine Company, Meadow Hall Works, Sheffield, is known to have built two vertical boiler locomotives, but the details preserved in the archives of the makers are meagre in the extreme. Apart from some photographs of two, the date of order of one and the laconic note "Tramway Locomotive," against Order No. 358, nothing further is known. These two locomotives were of different design, and each one may be regarded as experimental. A tramway locomotive, to be built under the patent of Mr. Loftus Perkins, was ordered on October 9, 1873, in the name of T. Vancamp. This was delivered early in 1874 to the Belgian Street Railway Company, Brussels, and for particulars of its construction we are indebted to a contemporary engineer, the late D. K. Clark, who recorded this locomotive in his *Tramways: Their Construction and Working*.

The vertical boiler and vertical engine were placed side by side and along each side of the frames was an air-cooled condenser, consisting of a series of ¼in copper tubes set vertically: into them the exhaust steam was discharged. The two condensers together presented between 700 and 800 square feet of cooling surface to the action of the atmospheric air. The upper ends of the tubes were closed except for a small opening, about ⅛in diameter, left for the escape of possible vapour. The boiler was constructed on Loftus Perkins's patented water-tube system, consisting of bent wrought iron tubes 2¼in diameter inside, and ⅛in thick, and proved to a pressure of 2500 lb





Figs. 12 and 13—Loftus Perkins high-pressure tram locomotive by the Yorkshire Engine Company, 1873, for Belgium

per square inch. The engine worked at the high pressure of 500lb per square inch with compound cylinders, one single-acting of 2⅞in diameter and the other one double-acting of 4¾in diameter, with a gear ratio between the crankshaft and intermediate shaft of 3 to 1. From this intermediate shaft the drive to the wheels was by coupling rods.

The wheels were 2ft diameter, while the total weight in working order was only 4 tons. Through the courtesy of the Yorkshire Engine Company it has been possible to illustrate this locomotive by the two photographs reproduced here as Figs. 12 and 13, which clearly show the principal constructional details. The guard rails round the sides and at the ends seem to indicate that this locomotive was not enclosed in the usual all-over cab.

We now have to consider a second and very mysterious and little-known locomotive shown here in Fig. 14. Mr. Ockendon, chief draughtsman at the Meadow Hall Works, has informed the writer that no documentary evidence now exists relating to this locomotive, except the official photograph reproduced here.

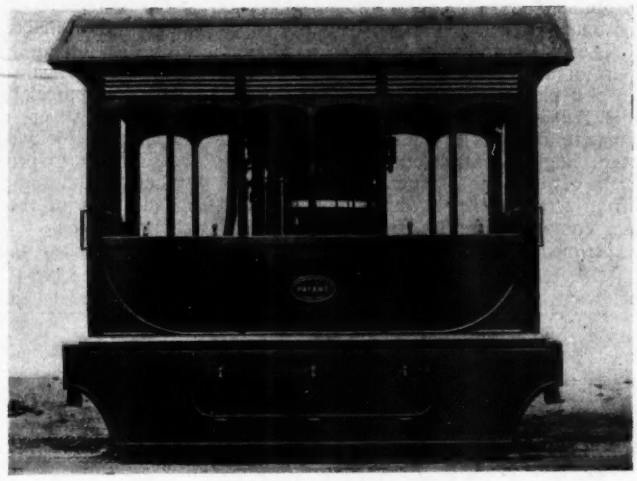


Fig. 14—Experimental locomotive by Yorkshire Engine Company, 1878, for trials on Sheffield tramways

But, according to an article by C. C. Hall, which was published in the *Tramway Review*, No. 5, third quarter, 1951, this locomotive is said to have been built in 1878 for experimental work on the Sheffield tramways, on which system it ran during October of that year.

At the time of the trials it was described as having two 7in diameter cylinders and developing 20 h.p. with a weight of 4 tons 15 cwt empty and 6 tons full.

(To be continued)

Design of Two-Dimensional Entrances to Hydraulic Channels

By N. T. BLOOMER, E. MARKLAND and G. POWER

At the inlet to a channel leading from a reservoir, it is common hydraulic practice to provide a flared section by which the fluid is guided smoothly into the entrance of the channel. Provided that the entrance is generously rounded, the precise shape of the curve is not of great importance in most engineering applications, but where it is desired to produce a steady uniform flow at the mouth of the channel, the question of the choice of a suitable shape of the inlet does arise.

A considerable amount of work has been done in the aerodynamic field on the related problem of the shape of the contraction just upstream of the working section of a wind tunnel. The ideal shape is one which produces uniform velocity across a section downstream of the contraction, and for which the pressure along the wall falls continuously without a reversal of gradient from the upstream to the downstream section. It is found theoretically, however, that a contraction of finite length cannot satisfy both of these conditions completely, and since considerations of space and cost usually limit the available length, the problem becomes one of finding a compact shape which will give only a small unfavourable pressure gradient over a short length of the wall.

The present work deals with three of the many possible types of curve which may conceivably be used to form the inlet of a two-dimensional channel leading from a large reservoir. Each of the shapes has been deduced analytically, and is designed to give a desirable pressure gradient along the wall. A representative example has been chosen for experimental verification of the analysis in each case. Models made in paraffin wax, reinforced by a small proportion of bees-wax, were carefully hand shaped to the required profile, and supported between parallel planes 4in apart. These planes formed the entry flare to a channel of rectangular section measuring 2in wide by 4in deep. Air was drawn into the channel at a speed of about 100ft per second so that the Reynolds' number of the flow, based on the width of the channel, was about $1{\cdot}2\times10^5$. Pressure measurements were made at holes on the surface of the curved wall at mid-height

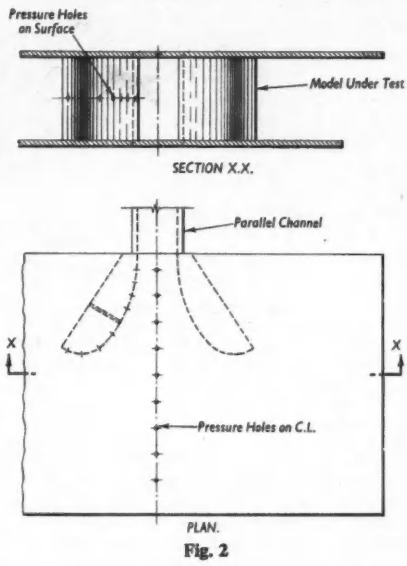


Fig. 2

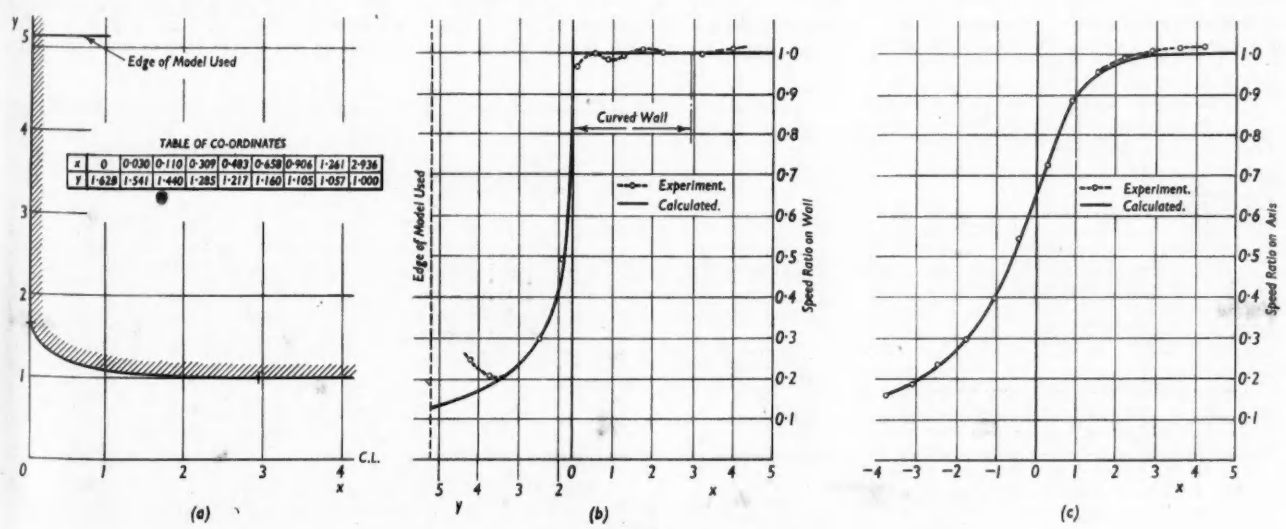


Fig. 1

and at holes on the surface of one of the parallel planes along the line of symmetry of the channel, as indicated on Fig. 2.

The first model tested represented a curve joining the edges of an aperture in the plane wall of a reservoir to the mouth of a parallel-sided channel, and was calculated to give constant velocity along the curve, which therefore represents a free streamline of flow from the reservoir into the channel. The distance between the wall of the reservoir and the mouth of the channel is a matter of choice ; in the limiting case where the channel recedes to an infinite distance from the wall, the solution for the free discharge from a two-dimensional slit is obtained. For a curve of finite length, the speed rises from zero along the plane wall of the reservoir, is constant along the curve, and falls asymptotically to its final value along the plane wall of the channel. This fall may be made as small as desired by lengthening the curve sufficiently, and in the model tested the dimensions of which are given on Fig. 1(*a*), the calculated speed along the curved boundary is about 0·7 per cent greater than the asymptotic value. Comparison between calculated and experimental results (velocities being deduced from measured pressures on the assumption of constant energy incompressible flow) is made graphically on Figs. 1(*b*) and 1(*c*). Close to the edge of the model, where the boundary starts, there is a region where measured velocities are higher than the calculated values, and this is probably due to separation of flow at the sharp corner and a subsequent reattachment. Measured speeds along the curved wall fluctuate in a random manner about the calculated constant value. Along the axis of symmetry, exceptionally good agreement is obtained up to the point where the channel becomes parallel.

The second model was made to represent part of an infinite curve, being asymptotic to the plane wall of the channel. From Fig. 3(*a*) it will be seen that the part of the curve tested turns through rather more than a right angle. Calculated speeds along the wall of this model increase continuously from zero to the asymptotic value, and are compared in Figs. 3(*b*) and 3(*c*) with experimental results. Again, there is a discrepancy due to the sharp edge of the model, but, in contrast with the previous one, there is almost perfect agreement close to the narrower portion of the entry. This may be due in part to a more accurately formed model, since the limit of accuracy of manufacture was about 0·01in, representing 1 per cent of the half width of the channel. It is also probable that a specified error in the shape of this model, where the pressure falls continuously along the wall, will have a lesser effect on velocities downstream of it than in the previous case, where the pressure should be constant over the curved part of the wall.

The third model represented a curve of finite length, being one-half of a curve which is symmetrical about the axis of y in Fig. 4 (*a*). This curve is terminated on the axis of symmetry and joins on to the parallel-sided channel. Across the throat the streamlines are parallel to the x axis but the calculated velocity is not quite uniform, the degree of non-uniformity being a function of the length of the entry flare chosen. For the particular shape shown on Fig. 4(*a*), the calculated variation in velocity is about 1 per cent, being higher at the wall than at the centre line. Calculated speeds along this curve increase continuously to a maximum at the throat, and are compared with experimental results in Figs. 4(*b*) and 4(*c*) ; the agreement is again good. It may be noted that if an appreciably shorter curve from the same family were chosen, the variation of calculated velocity across the throat may well be sufficient to produce a region of falling velocity and rising pressure close to the wall at the start of the parallel portion of the channel.

To summarise the results, it may be said that three possible designs of entrance shapes to a channel leading from a large vessel of fluid have been shown to have no appreciable reversal of pressure gradient along the surface, and the difference in measured velocity close to the wall and at the centre of the channel at the throat is small. Models made to an order of accuracy which it should not be difficult to reproduce in engineering practice accelerate the fluid in a manner corresponding closely with calculation, discrepancy occurring close to the sharp edge at which the models start. Although this close correspondence is to be expected in flows free from adverse surface pressure gradients, it has been considered worth while to report the results of actual tests.

Regarding the choice of the most suitable nozzle shape, it may be noted that the first one is unlikely to find practical application unless it were desired for some reason to form an entrance curve with constant pressure along its length. It would generally be preferable, in the case of a channel leading from the plane side of a reservoir, to use the appropriate portion of the curve of the second type. (The calculated velocity along the curve at a point where its tangent is at right angles to the centre line is less than 0·2 of

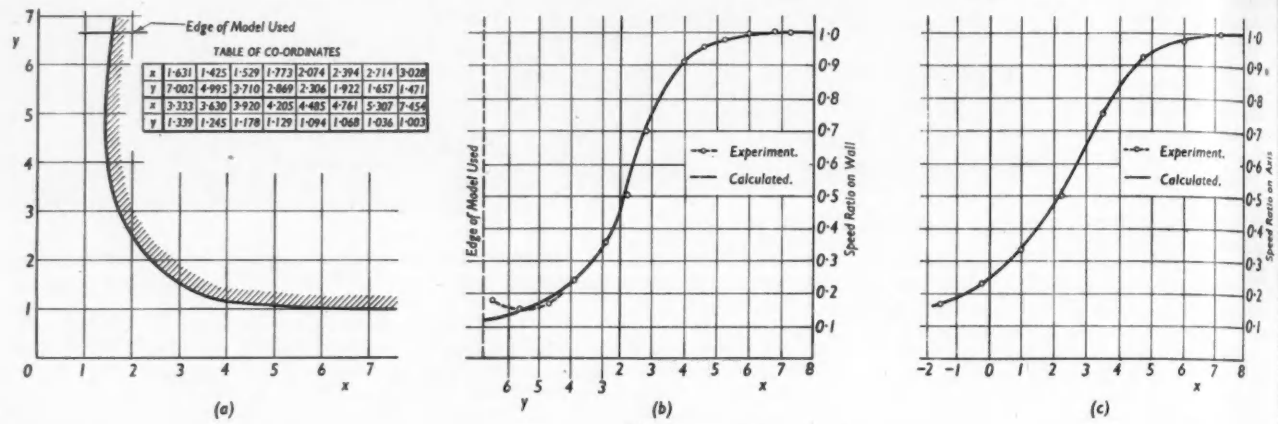


Fig. 3

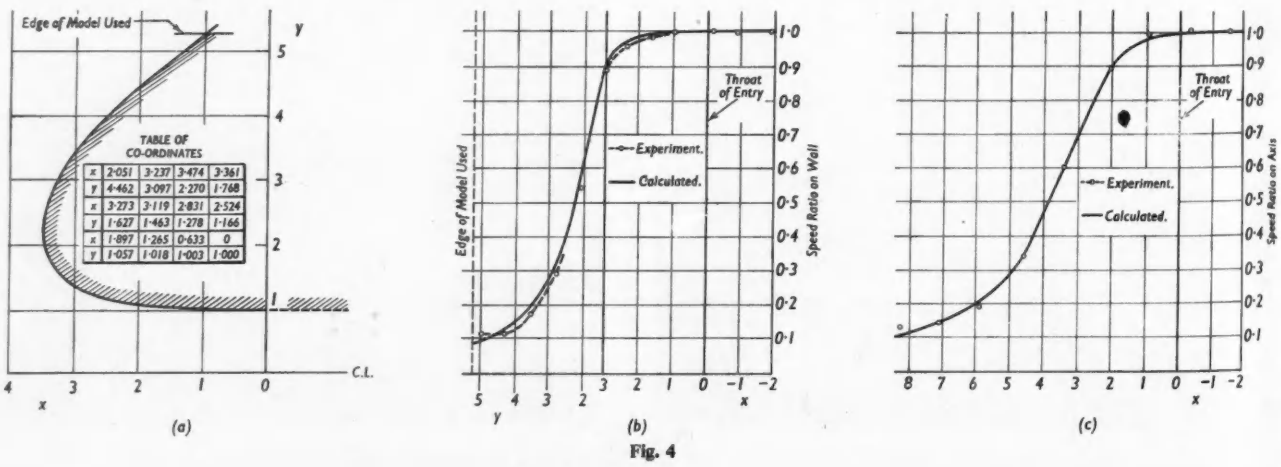


Fig. 4

the speed in the channel.) If the channel were extended into the body of the reservoir so as to start from a point well removed from the wall, then, in view of its compactness, the third type of entrance would appear to be most suitable (the calculated velocity along the curve at a point where its tangent is at right angles to the centre line being about 0·5 of the speed in the channel).

We now turn to the analysis by which the curves were derived ; it is emphasised that transformations other than those given below are appropriate to the problem.

(1) The transformations

$$t+a=e^{\pi w} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and

$$A\frac{dz}{dt}=\frac{(t+1)^{\frac{1}{2}}+(t-1)^{\frac{1}{2}}}{t+a} \quad . \quad . \quad (2)$$

in which a and A are arbitrary constants, convert the shaded portions of the w-plane and the z-plane into the upper half of the t-plane as shown in Fig. 5, the boundary in the z-plane being made up of straight lines

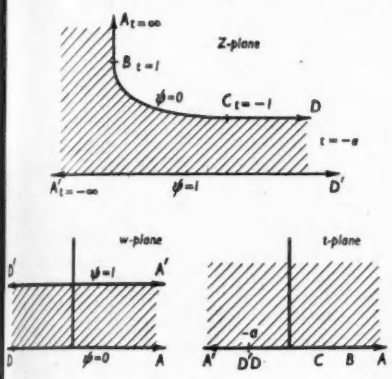


Fig. 5

AB and CD at right angles, joined by the curve BC which is tangential to these lines. A relationship between w and z may be obtained by eliminating t from equations (1) and (2) ; the fluid speed q at any point in the resulting irrotational motion is given by :

$$\frac{dz}{dw}=-\frac{e^{i\theta}}{q} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

From (1) and (2) it follows that

$$-\frac{i}{\lambda\pi}\frac{dz}{dw}=(t+1)^{\frac{1}{2}}+(t-1)^{\frac{1}{2}} \quad . \quad . \quad (4)$$

where λ is defined through the relations

$$b=|(a-1)^{\frac{1}{2}}|,\ c=|(a+1)^{\frac{1}{2}}|,\ \lambda=\frac{1}{\pi(b+c)} \quad . \quad (5)$$

The results of integration are as follows :—

For $t<-a$,

$$\left.\begin{aligned}-x&=2\lambda d+b\lambda\log\left(\frac{d-b}{d+b}\right)+2\lambda B\\&\quad+\lambda c\log\left(\frac{B-c}{B+c}\right)\\y&=0\end{aligned}\right\} \quad . \quad (6a)$$

in which

$$d^2=-1-t,\ B^2=1-t.$$

For $-a<t<-1$,

$$-z=2\lambda d+\lambda b\log\left(\frac{b-d}{b-d}\right)+2\lambda B+\lambda c\log\left(\frac{c-B}{c+B}\right)-i \quad . \quad . \quad . \quad (6b)$$

For $-1<t<1$,

$$-z=-2\lambda i(\mu-b\tan^{-1}\mu/b)+2\lambda B+\lambda c\log\left(\frac{c-B}{c+B}\right)-i \quad . \quad . \quad . \quad (6c)$$

in which

$$\mu^2=1+t.$$

For $1<t$,

$$-z=-2\lambda i(\mu-b\tan^{-1}\mu/b)-2\lambda i(\theta-c\tan^{-1}\theta/c)-i \quad . \quad . \quad . \quad . \quad (6d)$$

in which

$$\theta^2=-1+t.$$

The numerical value of a chosen for the experimental work was 1·0001, and the value of q along the curved boundary in this case is 0·7 per cent greater than the final velocity in the channel.

(2) To obtain an entry shape of infinite length, consider the transformation

$$\frac{dz}{dw}=-\left(1-ie^{w\pi/b}\right)^n \quad . \quad . \quad . \quad . \quad (7)$$

in which

$$0<n<2.$$

The streamlines in the z-plane shown on Fig. 6 become asymptotically parallel to

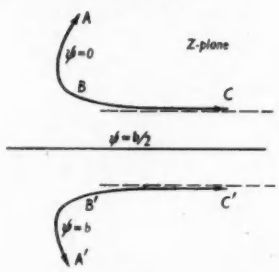


Fig. 6

the x-axis at C and C', and inclined at angles $\pm\frac{n\pi}{2}$ to the x-axis at A and A'. The speed increases continuously along all streamlines within the range $0<\psi<b$. In the particular case when $n=2$, equation (7) integrates to give

$$z-\frac{ib}{2}=-w+\frac{2ib}{\pi}e^{w\pi/b}+\frac{b}{2\pi}e^{2w\pi/b}+\frac{5b}{2\pi} \quad . \quad (8)$$

choosing the constants of integration such that

$$z=0 \text{ when } w=\frac{ib}{2}.$$

Streamlines ABC and $A'B'C'$ of Fig. 6 or any pair of streamlines within them may be

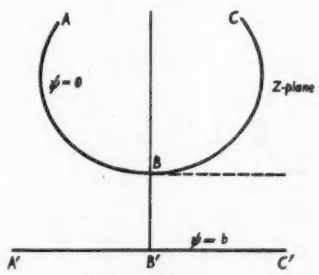


Fig. 7

used to form an entrance to the channel ; the particular shape chosen for experiment was obtained from Equation (8) putting $\psi=b/8$.

(3) Consider, thirdly, the transformation

$$-\frac{dz}{dw}=\left(1-\frac{i\sinh w\pi/b}{\lambda}\right)^2 \quad . \quad . \quad . \quad (9)$$

in which λ is real and positive. This integrates to give

$$-z=(1+\tfrac{1}{2}\lambda^2)(w-ib/2)-(2ib/\lambda\pi)\cosh w\pi/b-(b/4\lambda^2\pi)\sinh 2w\pi/b \quad . \quad . \quad (10)$$

choosing $x=y=0$, when $\phi=0$, $\psi=b/2$, and the boundaries are sketched in Fig. 7. The streamlines are parallel at points on the y-axis between B and B', and the speed increases continuously along every streamline. The speed is, however, not constant across the throat BB', varying from

$$1 \text{ at } B'$$

$$\text{to } \frac{1}{(1+1/\lambda)^2} \text{ at } B.$$

The particular value of $1/\lambda$ chosen for the third model was 0·005, which therefore gives about 1 per cent variation of velocity across the throat.

ACKNOWLEDGMENTS

The work was conducted in the laboratories of the engineering departments of the University of Nottingham, and the assistance given by the head of the departments, Professor J. A. Pope, D.Sc., in placing these facilities at our disposal is gratefully acknowledged.

Short Notices

Engineering in Agriculture. By P. H. Southwell. London : Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 30s.—One of the problems created by the rapid progress of mechanised agriculture is that of educating farmers and operatives in the effective use and maintenance of their machinery. Undoubtedly there are many people engaged in agriculture who feel the need for an explanation, in simple language, of some general engineering principles. Mr. Southwell has set out to supply that need. His book includes not only basic data and chapters on such matters as heat and combustion, machines and mechanisms, hydraulics and electricity, but also on the strength and properties of materials and on earthworks and surveying. Although the book may have been designed primarily to assist the mechanised farmer and his staff, those who are engaged in the business of agricultural engineering will find it of considerable value as a work of reference.

Analysis of the Premature Structural Failures in Static Tested Aircraft. By L. S. Jablecki. Zürich: Verlag Leemann, Arbenzstrasse 20. Price 12.50 francs.—In this paper Dr. Jablecki discusses the static tests carried out by the United States Air Force between 1940 and 1949, a full summary of which is given in an appendix. Test methods and the various types of failure observed are described in detail, together with improvements which could be made in the basis of the tests. In this way the author hopes to throw some light on the question whether anything could be done to reduce the number of failures, especially those occurring at under 80 per cent of the design ultimate load. For each of the various aircraft components under test a curve of ultimate load against expectancy of failure may be plotted, and the particular shape of this curve is stated to reflect the design errors or inadequacies of analysis which caused the component to fail.

Mix Design and Quality Control of Concrete. London : Cement and Concrete Association, 52, Grosvenor Gardens, S.W.1. Price 45s.—The proceedings of the symposium on mix design and quality control of concrete, held in London in May, 1954, are published in this volume. There are in all twenty-two papers, with the discussions, introductory addresses, and so on, of the symposium. Considerable interest was shown in the symposium when it was held last year, and the present volume provides a record of contemporary British thought and practice in this subject and indicates various unsolved problems, and directions in which further progress may be expected. Many of the authors and contributors are well known, and the points of view of the practising engineer, both consultant and contractor, and of the research worker, are all represented.

German Industries Fair, Hanover

No. IV—(*Concluded from page 746, May 27th*)

WE conclude our descriptions of engineering exhibits shown at the recent German Industries Fair held at Hanover.

Dinglerwerke Aktiengesellschaft

A range of plant for the preparation and finishing of road surfaces was shown by the Dinglerwerke Aktiengesellschaft of Zweibrüken, in the Rheinpfalz. Several of these machines have recently been further developed in design. They included concrete spreaders, vibration finishing machines and joint cutters and grinders.

Here we describe a new vibration roller "VR–10," which is shown in Fig. 24. It is a neat machine with the operator seated behind the main roller over the steering roller, which is made in two parts, both of which are combined in a carden-like system of suspension. The machine is adjustable for a rolling capacity from 2 up to 10 metric tons. The frequency of the vibrating roller is 50 c/s, the diameter of the main roller is

Fig. 24—Vibration road roller—Dinglerwerke A.G., Zweibruken

800mm and that of the steering roller 420mm, with a distance between the roller centres of 1050mm. The overall length of the machine is 3110mm and its height 1440mm. The overall width of the roller is 1270mm. The travelling movement is transmitted through a totally enclosed gear, and two gear changes are provided. In first gear the travelling speed is 1·1km per hour and in second gear it is 2·2km per hour, both backwards and forwards. The total weight of the roller is 1800 kg and the power required is about 12 h.p. The roller was demonstrated in operation and we noted that a very compact and smooth surface was obtained, and there was no shifting of the material in front of the steering roller. Another model of the same machine was also on view. It was of the tandem form with the operator seated between the front steering roller and the rear vibrating roller. The Dinglerwerke A.G. is represented in the United Kingdom by the firm of P. H. Meyer and Co., Ltd., 6, Drapers Gardens, London, E.C.2.

Maschinenbau Kiel Aktiengesellschaft

On the stand of the Maschinenbau Kiel Aktiengesellschaft there was shown an example of the company's standard 600-8 MaK diesel-hydraulic locomotives, which are already in service on various lines of the German Federal Railways, and are engaged in local passenger, goods traffic and shunting operations. This same type of locomotive with modifications has been adopted on the railways of Norway and Sweden, and has been tried out in Ireland on the lines of the Great Northern Railway Board.

As will be seen from Fig. 25, the locomotive has four axles, the eight wheels being driven by coupling rods from the centre jack shaft, immediately below the driving cab. The two pairs of axles, forward and rear, are combined on the Beugniot bogie principle which is designed to give increased flexibility on curves. According to the duty, the locomotive may be fitted with a 600 h.p. engine running at 750 r.p.m., or an 800 h.p. engine running at the same speed, these being six and eight-cylinder units respectively, having a cylinder bore of 230mm and a stroke of 300mm. The engines work on the four-stroke principle, either with a precombustion chamber, or with direct-injection. With the 600 h.p. engine the locomotive weighs about 52 tons, and with the 800 h.p. engine 56 tons. The drive from the engine is taken through a "Periflex" coupling and a cardan shaft to a Voith L37 hydraulic transmission, comprising a converter and two fluid couplings which is followed by the driving and reverse gears. Brown-Boveri exhaust gas turbo supercharging is fitted. The oil engine and its auxilary engine driven pumps are accommodated in the forward casing, and the hydraulic drive is arranged below the driving cab. The rear casing can be used for an exhaust gas boiler for train heating. The driving cab is set high, and a good view in both directions is obtained. The driving

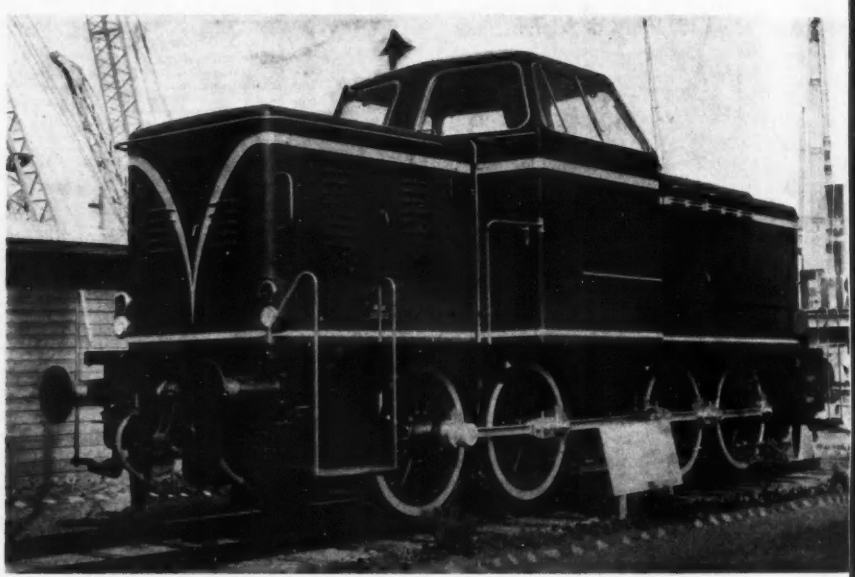


Fig. 25—Diesel-hydraulic four-axle locomotive—MaK

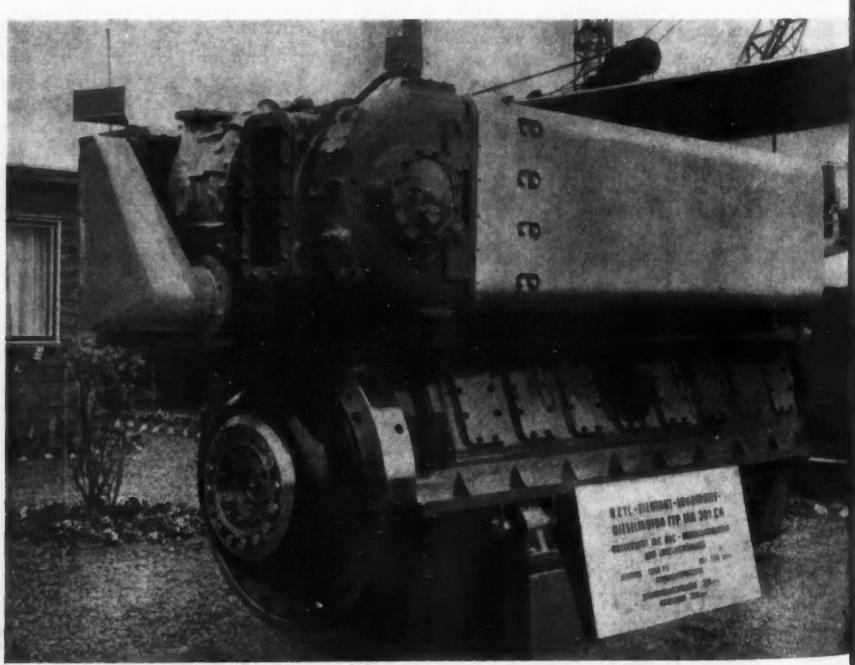


Fig. 26—1000 h.p. locomotive engine with exhaust gas turbine supercharger and after-cooling of charging air—MaK

cab is insulated by rubber from the frame structure, and from the engine casing by a leather bellows. As will be seen from the photograph, good access is given to the engine and rear casings by side doors and also a sliding roof. When the engine is required to perform shunting duties, the buffer beam is shortened and wide steps for the use of the shunter are provided.

Another exhibit on the MaK stand was the MA 301 CK locomotive engine, one of the latest units to be specially designed for locomotive work, a view of which is given in Fig. 26. It is an eight-cylinder four-stroke engine working with direct-injection and it has a designed output of 1000 h.p. at 750 r.p.m. The cylinders have a bore of 230mm and a stroke of 300mm. As will be seen from our illustration, the Brown-Boveri exhaust gas turbine driven blower is mounted at the end of the engine, and along its sides are intercoolers which are utilised to cool the charging air before it reaches the engine cylinders. In addition to the locomotive engines we have referred to, the MaK firm also manufactures engines for driving electric generators and for oil-field machinery.

Fig. 28—New submersible salvage pump—Pleuger Co.

Pleuger Unterwasserpumpen G.m.b.H.

Some new developments in the design and uses of submersible pumps were indicated on the stand of Pleuger Unterwasserpumpen G.m.b.H., of Hamburg-Wandsbek Friedrich-Ebert Damm 101. Following successful experience with the salvage type of pump in the Dutch floods, the pump has now been developed as a bilge pump aboard ship and in mining work. It has been installed in the new fishery vessel "Anton Dohrn," which also has one of the firm's patented "active rudders" of 100 h.p. The new design of salvage pump is illustrated in Fig. 28. In contrast to the earlier designs, the new unit has the driving motor arranged above the pump. By this means the first stage of the pump entrains the water, which is then by-passed to the pressure outlet at the top of the pump, on which any type of fire hose can be fitted. As the motor is above and clear of the pump, dirty water can safely be dealt with, and the pump is protected against infiltration of dirt and sand into the motor and its thrust bearing. With such a pump, sumps and pits can be drained down to a water level of 4in. This year, also, the first example of a Pleuger submersible oil pump was shown. It can easily be installed in a borehole, and it has a diameter of 135mm or about 5⅜in and weighs 90 kg, or just under 200 lb. All parts subject to wear are interchangeable and can quickly be replaced.

The "Ventimotor" wind-power plant, to which we referred in last year's Fair article, has been developed further, and is now available with a.c. and d.c. generators, or alternating and direct current combined. By this means lighting and power loads may be supplied and, in addition, water supply can be maintained by using a newly developed d.c. pump which can be connected to the accumulator battery.

The Pleuger Company is represented in this country by British Pleuger Submersible Pumps, Ltd., of Birmingham.

Salzgitter Maschinen A.G.

An outstanding exhibit in the open-air exhibition ground was the modern oil boring equipment shown by Salzgitter Maschinen A.G. the wagon of which we illustrate in Fig. 27, and the mast in Fig. 29. The plant is designed for all kinds of work in oilfields, and will make bores up to depths of 1000m using A.P.I. boring tools, of 4½in diameter. It can be utilised for production work in the draining and cleaning of boreholes and can also be applied to completion work in depths up to 2000m.

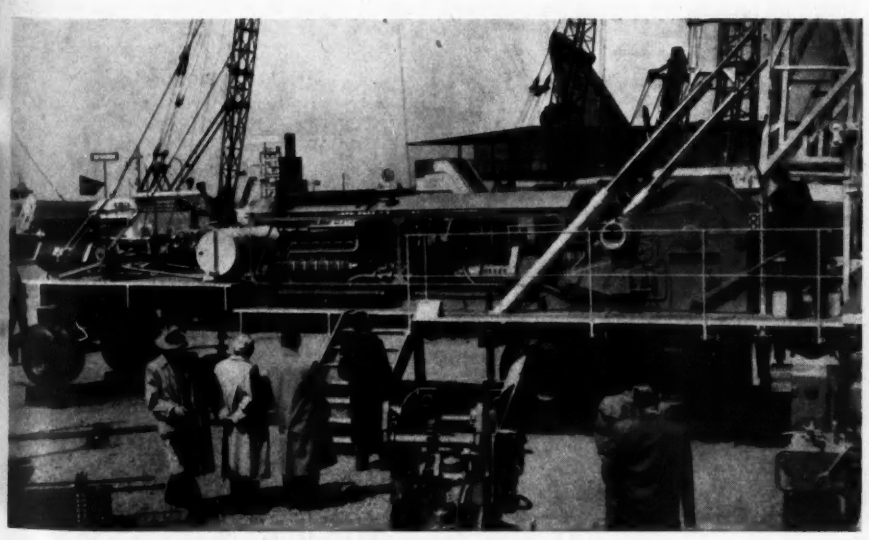


Fig. 27—Trailer and base of oil boring plant—Salzgitter Maschinen A.G.

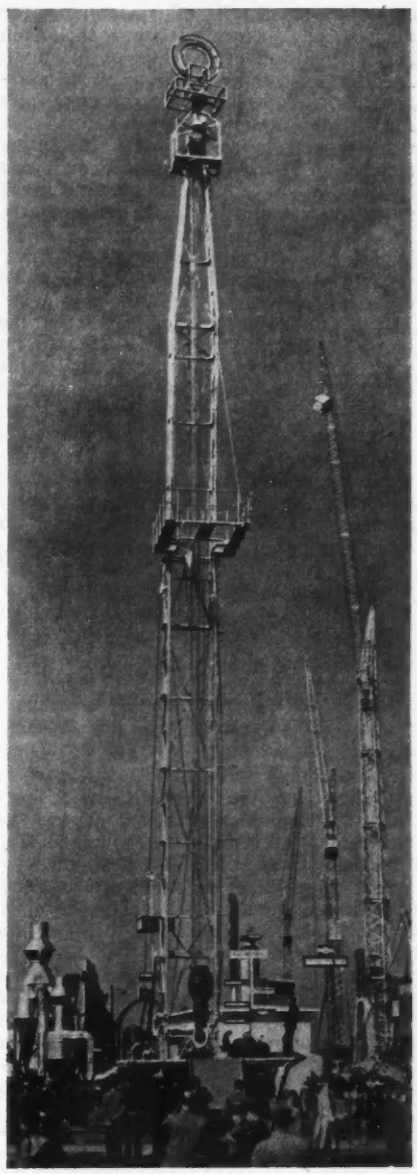


Fig. 29—Mast of oil boring plant—Salzgitter Maschinen A.G.

The driving engine, auxiliary machinery and winch gear, are accommodated on a three-axle trailing wagon with pneumatic tyred wheels (see Fig. 27) which has a carrying capacity of about 20 tons. The engine is a 200 h.p. air-cooled Klockner-Humboldt-Deutz diesel motor, running at 2000 r.p.m. Air starting with its special air compressor is provided. When working, the load is taken off the wheels by means of eight heavy screw supporting pillars. The power for the boring tools and the revolving table is transmitted through a Zöllner fluid coupling working on the Föttinger principle which has a high efficiency, and there follows a six-speed laminated coupling with reverse motions. The winding gear has a rope drum driven by means of a Westinghouse chain and two Fawick-Airflex couplings, giving a 9·5-ton pull. The double band-brakes for the rope drum are hand operated. Two rope capstans can also be coupled to the six speed gear and are pneumatically operated. The coupling is electrically

controlled, and all other motions are preumatically controlled from the main control platform at the side of the mast. A special air compressor provides the necessary air. As will be clearly seen from Fig. 29 the tower is constructed in rectangular section with lattice supporting members. When travelling the mast can be lowered on to the trailer, and when ready for operation it can be raised by the hydraulic cylinders, to be seen in Fig. 27, in a few minutes. The mast is equipped with rollers for the rope, which allow an eight part reeving of the block and tackle. The platform for assembling the boring tools, is designed to allow the 1600m of A.P.I. 4½in rod to be assembled in lengths of 18m. The mast has a total height of 30·7m, and its lifting capacity at the crown is 80 tons with a maximum lifting capacity of 100 tons. The 20½in revolving table has a 2m high service structure, which permits the convenient erection of the boring tools. For the supply of water needed in boring operations, a special twin double-acting pump with a 5in bore and a 10½in stroke is provided. The total weight of the complete plant is about 27 tons.

Klockner-Humboldt-Deutz A.G.

An interesting exhibit on the stand of Klockner-Humboldt-Deutz A.G., of Cologne, was the trailer, shown in Fig. 30, on which two identical power units, each comprising a single-cylinder diesel engine driving an alternator of 10kVA capacity, are housed. The object of this special arrangement is to provide a power plant which, in case of need, can run continuously. Each of the units, for example, could be run alternately for twelve hours, the other being shut down. As will be seen from the illustration, the plants can be run on the trailer, which is supported by screw legs, or they can be carried away to form stationary units. Such units have been found very useful for emergency pumping plants and conveyors, and for signalling installations for the safety of aircraft.

A new shunting locomotive is illustrated in Fig. 31. It has a service weight of 28 tons and the power unit is the air-cooled, 200 h.p., twelve-cylinder, diesel engine, type A12L 614, which was first shown in Hanover at last year's Fair. This shunting locomotive is one of a series now under course of manufacture at the company's Kalk factories,

The Klockner-Humboldt-Deutz A.G. is represented in Great Britain by A. Kracko, Ltd., 24, Drewstead Road, London, S.W.16.

Vereinigte Armaturen Gesellschaft M.B.H.

The Vereinigte Armaturen Gesellschaft M.B.H., of Mannheim, showed on its stand several new developments in valve design. A new kind of sluice valve, specially designed for mining work, is shown in Fig. 32 to the left. It will be seen that compared with the

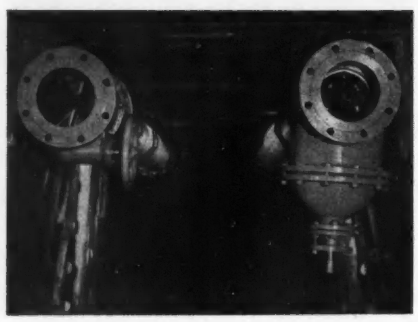


Fig. 32—"Elita" rotary disc valve for mining work—Vereinigte Armaturen

normal type of sluice valve shown on the right, the new valve is much smaller and neater and gives clear headroom when installed along the roof of a mining gallery.

For a pressure of 142 lb per square inch its height is only half that of the conventional

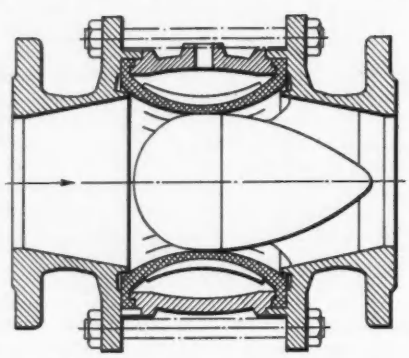


Fig 33—"Hydro-Seal" valve—Vereinigte Armaturen

sluice valve. The "Elita" rotary disc valve has a rotating disc which is divided into four segments, two being open and two closed. The two flow apertures can be opened or closed by rotating the central plate through an angle of 90 deg. by means of the worm gear. A 6in mine valve only needs ten spindle revolutions to open or close it, as compared with some thirty-six revolutions for an ordinary sluice valve of the same diameter. The valve body is cast in spheroidal graphite iron.

Two interesting new developments which make use of a longitudinally pleated diaphragm, and are the subject of German patent applications, were shown for the first time and are illustrated in the drawings, Figs. 33 and 34, both of which show the valves in the closed position. The "Hydro-Seal" valve shown in Fig. 33 has very small dimensions compared with standard hydraulically operated valves. The closing is effected by a cylindrical longitudinally pleated diaphragm, which is pressed against

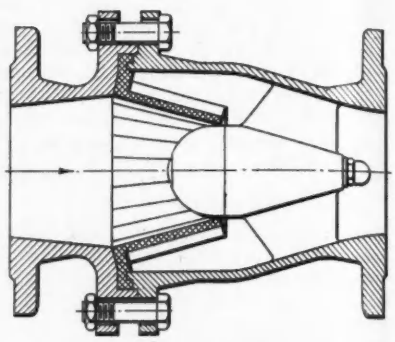


Fig. 34—"Hydro-Stop" valve—Vereinigte Armaturen

a streamlined central body. Water or some other liquid, or gas under pressure which is collected, between the outer casing and the diaphragm, presses the flexible diaphragm on the streamlined body. The width of the diaphragm pleats, which run in the direction of water flow, are so designed that the slits close just before the inner surface of the diaphragm touches the central body. This gives a pressure-and vacuum-tight closure. The valve can be operated by water, as with all hydraulic valves, a three-way cock being employed to control the activating medium. Experience with this type of valve has shown, we understand, that the pleated diaphragm is durable compared with the mechanical wear of metals, as the angle of deformation when closing is quite small.

The other valve operating on a similar principle is the "Hydrostop" valve shown in Fig. 34, and is a new type of non-return valve. Again a pleated diaphragm of highly

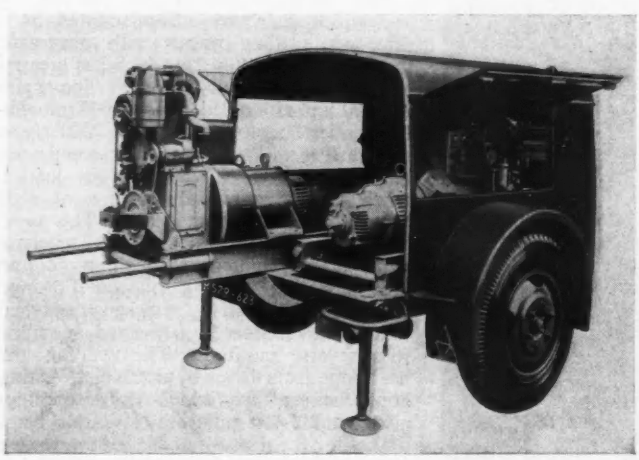


Fig. 30—Trailer with two 10kVA power units—Klockner-Humboldt-Deutz A.G.

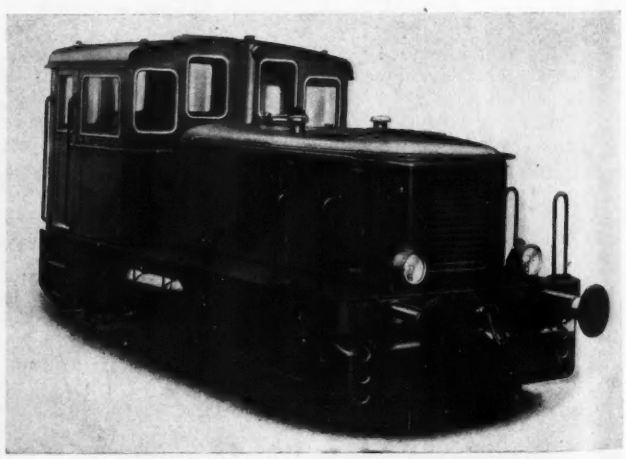


Fig. 31—28-ton, 200 h.p. shunting locomotive—Klockner-Humboldt-Deutz A.G.

resilient material is used which closes against a streamlined body. The general design of the valve body and diaphragm allows for a low mass effect. When the flow is reversed the diaphragm is immediately pressed against the streamlined body and the operation is silent, doing away with water hammer and the noise of flap-valves. All the valves made by the firm which have stuffing-boxes are now fitted with a new kind of packing, which is patented and termed "Immerdicht," or "Permanent" packing. With this new form of packing the stuffing-box has an elastic ring packing, at the bottom and top, above and below which are steel rings which separate the elastic rings from the main central hemp-tallow packing which, thus isolated from the other packings, serves to lubricate the valve spindle. Very good results with this new form of packing have, we understand, been obtained.

Siemens-Schuckert Aktiengesellschaft

An exhibit shown on the outdoor stand of the Siemens-Schuckert Aktiengesellschaft, of Berlin, Siemensstadt and Erlangen, was the 1470kW motor designed and built for a cold rolling strip mill. It is one of four such motors. It is supplied with 800V current and has a variable speed between 80 and 180 r.p.m. In order to keep the inertia as small as possible to permit quick speed changes the diameter of the armature has been reduced to 1800mm with a length of 1080mm. More than fifteen years ago armatures of 2500mm diameter were used, with a length of 560mm, having double the inertia. In the range from 80 to 180 r.p.m., between which the motor must work at constant load, the speed is changed by variations in the strength of the magnetic field, while from starting up to 80 r.p.m. the motor is controlled by changes in the armature voltage. The windings of the motor are so designed that with a 25 per cent overload the temperature does not rise above 65 deg. Cent. The insulation is designed for a working voltage of 1200V, the normal voltage being 800V. The motor is totally enclosed and can be directly coupled to the rolling mill. The housing is in two parts, the massive centre ring of the magnetic yoke piece, and the side covers made of steel plate sections. Forced ventilation is used, whereby the inner parts of the motor are subjected to a somewhat higher pressure, which effectively keeps out dangerous dust and metal particles. The cool air for the motor is introduced on the working side into the ventilator and streams through slots in the plate sections and cools the armature windings and the stator windings. From here it can stream outwards through the openings in the side plate sections and there are also openings above which allow part of the air to stream over the stator casing. Some of the heated air is allowed to return to a storage chamber in the foundation pit, from which it goes through a cooler and is again delivered to the motor. The commutator and brushes are cooled through a separate passage and any commutator dust is removed by a filter. The commutator casing is furnished with windows and the cover can be swung back to give free access to the commutator and the brushes.

Allgemeine Elektricitats-Gesellschaft

This year the Allgemeine Elektricitäts-Gesellschaft, of Berlin-Grunewald and Frankfort, gave special attention to the developments which have taken place in the electrical industry to regulate and quicken manufacturing and finishing processes by the use of electric and electronic equipment. Several models were on view showing these applications. In the high-tension section considerable interest was shown in the open-air exhibit of switchgear for 220kV and 380kV. The A.E.G. multi-break free-jet circuit breaker, which went into service for the first time last autumn, was shown. In Fig. 35 we give a section through this double-headed multi-break free-jet air blast circuit breaker. It will be seen that the heads are supported on an insulator, through which the compressed air operating the breaker passes. The extinguishing heads to the left and right each contain the moving contact pins, which, under pressure, are forced out through the nozzle and make contact with the fixed contact piece in the depending horn-shaped member, which in its upper part contains a condenser. When the switch is opened the moving contact returns to its position inside the nozzle and the arc which takes place in free air is rapidly extinguished by the strong air blast through the nozzle. The high pressure within the nozzle and the cooling effect of the air blast prevent the arc from re-establishing itself. The moving contact is mechanically held in its end position as shown. After every switching operation the extinguishing head is blown through and is not under any pressure. Fig. 36 shows a number of circuits with the switches in the closed position. The layout of the circuit breakers in zigzag form, as shown, cuts down the area and particularly the length required for a large installation. The voltage conditions in a large high-tension overhead system make it necessary to provide an additional isolating switch, which takes the form of three similar pneumatically coupled single-phase units. The compressed air cylinders will be seen at the base of the circuit breakers, and this base also carries the pneumatic and electrical controls. The Hohlis type insulators form the supporting base, and through these —as Fig. 36 shows—the compressed air for operating the breakers and extinguishing the arcs passes.

The Allgemeine Elektricitäts-Gesellschaft is represented in Great Britain by the Welmec Corporation, Ltd., of 147, Strand, London, W.C.2.

Brown Boveri et Cie A.G.

On the stand of Brown Boveri et Cie of Mannheim, there was shown a model of a high tension overhead line with a mast of novel tubular construction. The mast is constructed according to the Motor-Columbus-Mannesmann designs. The four corner members of the mast are tubes filled with concrete, and the diagonal members are joined to them by air-tight joints. The section of the steel tube chosen is, of course, fixed by the stress it must carry, but as some stress is carried by the concrete filling, a much simpler construction is possible.

The filling with concrete prevents water from gaining access to the insides of the corner tubes, and protects the tubes from corrosion and frost damage. The lighter form of mast is easier to transport, and to erect on difficult sites. The Brown Boveri firm has collaborated closely with the Westdeutsche Mannesmann Aktiengesellschaft in working out problems connected with this new design of mast. Brown Boveri has also perfected special processes for the erection of the masts, and filling them with concrete. The foundations for the corner tubes, are centrifugally spun concrete tubes, with steel reinforced bases which are easy to erect, and do not need heavy excavations for foundations.

On another Brown Boveri stand there was to be seen an unusually interesting model of a mobile gas turbine driven electric generating plant, having a designed capacity of 6200kW. Two of these special plants are being constructed by Brown Boveri et Cie of Baden, Switzerland, for the Comision Federal de Electricidad Mexico. The whole

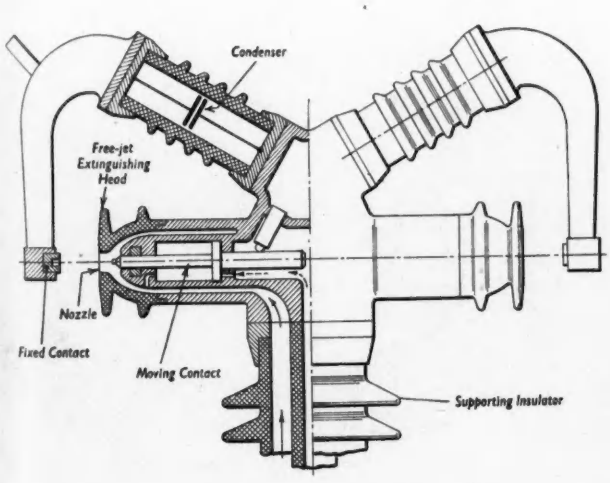


Fig. 35—Section through double-headed free-jet circuit breaker—A.E.G.

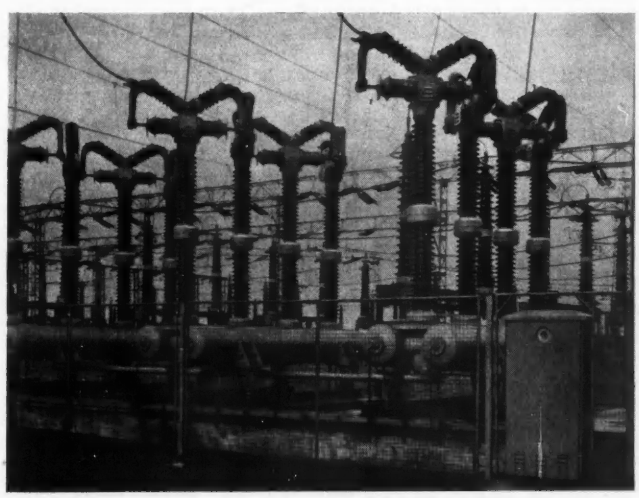


Fig. 36—Group of circuit breakers in closed position—A.E.G.

of the plant is assembled on two standard railway trucks. The first truck carries the gas turbine complete with its combustion chamber, its compressor and its starting motor, and also the alternator and its exciter. The current generated is fed by means of a cable to the second truck, which is equipped with a transformer and switchboard, and an emergency diesel engine driven generating set with the starter battery. The transformer enables power to be taken from the set at 13·8kV, 6·6kV, 4·16kV or 2·4kV. Oil fuel is supplied to the turbine from the accompanying oil tank wagons. The plant can be set to work in any spot near a railway line, to supply any network.

Repair of Ridham Dock

As a result of the East Coast floods of January–February, 1953, the west wall of Ridham Dock, a mass concrete structure 800ft long, moved bodily a distance of several feet and tilted to a considerable angle. This article describes the causes of the movement, the immediate temporary repairs carried out, and the permanent reconstruction of the wall.

RIDHAM DOCK stands on the south bank of the Swale, which is a channel of the Thames estuary separating the island of Sheppey from the mainland of Kent. The land at this point, like other low-lying areas adjoining the estuary, is normally protected from flooding by a river wall. The dock is the property of the Bowater Paper Corporation, Ltd., and serves the Corporation's Kemsley and Sittingbourne mills, to both of which it is connected by a private narrow-gauge railway. The products of these mills include newsprint, white printing papers, and fibreboard which is converted into heavy-duty containers in other factories of the Bowater organisation. The output of newsprint alone will amount in the near future to 250,000 tons per annum. The dock handles imports of raw materials for the manufacture of both paper and board, logs from Canada and Newfoundland for pulping ; wood pulp prepared by the Bowater pulp mills in Newfoundland and Scandinavia ; china clay from ports in the British Isles, and coal for the large power station which supplies both mills. It is also used for loading finished products on to barges which carry them to the London docks for transhipment and export. In 1952 381 shipments were handled, apart from barge traffic, and the total tonnage of cargo amounted to 750,000, or 550 per foot of quay—an exceptionally high figure. Ships up to 3500 tons cargo carrying capacity, 20ft draught and 315ft length, are accommodated.

Ridham dock was built in 1913 and is shown in plan in Fig. 1. Its length (north to south) is approximately 800ft ; its width was originally 250ft at the north (or entrance) end, decreasing to 150ft at the south end. Each of the side walls contains berths for two ships and barges berth at the south end. The walls as originally constructed were conventional gravity structures of mass concrete, 46ft high above their foundations, and carried narrow-gauge railway and crane tracks.

The following levels are to Ridham dock datum :—

H.W.O.S.T.	+12
L.W.O.S.T.	−5
Dock bottom :	
Designed dredged level	−19
Actual	−13
Top of walls	+17·5
Ground level	+ 9 approx.

It will be noted that ground level is several feet below H.W.O.S.T. The ground is clay, which at this point goes down to depths of at least 60ft or 70ft.

The west wall had already moved forward on a previous occasion, in 1922, and the east wall also had moved slightly in 1931. These movements were attributed to the exceptional loads on the ground behind the walls due to large stacks of wood pulp. In each instance repairs were necessary. The repairs effected after the movement of the west wall in 1922 probably prevented a more serious catastrophe in 1953. These repairs consisted in the addition of a new concrete toe and heel, which together increased the width of the base of the wall to 32ft. For the placing of the toe, steel sheet piling was driven on the water side ; this acted as a shutter for the concrete forming the toe, and its lower part was left in position on completion. On the landward side timber sheet piling was driven, and after placing of the new heel the trench was backfilled with ashes. These movements of the east and west walls and the repairs effected had reduced the width of the dock entrance from 250ft to 218ft.

When the exceptional tide of February 1, 1953, breached the main river wall of the Swale the floods on the land adjoining Ridham dock reached level +14 ; the water immediately behind the west wall was in fact about 6ft deep. As the tide fell the wall cracked and began to move forward into the dock basin. At each successive ebb the movement continued, with some tilting. After three days there was a breach 7ft wide at the north end and another 2½ft wide at the south end ; the centre of the wall had moved forward 9ft 3in and canted to a slope of 1 in 8. Subsequent investigations showed that in the conditions imposed by the floods the wall was unstable to the point of overturning ; if it had not been for the steel sheet piling driven as part of the earlier repairs and left in position the movement would have been more severe and the wall might quite possibly have overturned.

Consequential damage was considerable. The legs of a crane, which was placed behind the wall and used for stacking pulp, sank into the trench formed by the movement of the wall, and the crane collapsed over the wall with its jib resting on the bottom of the dock. A narrow-gauge locomotive and several trucks were completely submerged in this trench together with their tracks, and other rail and crane tracks were undermined as the flood waters escaping through the breaches washed out the ash filling behind the wall and formed secondary drainage channels across the adjoining land.

Repair Work

The first measure, which was put in hand immediately, was to form a clay bank about 200ft west of the west wall, with its north end joining the main river wall of the Swale, and with a return wall running from its south end to meet the south-west corner of the dock (Fig. 1). The first effect of this was to prevent the flood waters, which covered the land for miles around, from draining through the breaches at either end of the west wall. Later, as the floods subsided, it also served to contain the water flowing through the breaches in the opposite direction at each high tide, and thus to protect the land to the west from further periodical flooding.

Preparations were also immediately made for temporary repairs to the west wall, with the object of providing a usable berth on the south half at the earliest possible date, and before the beginning of the arrival season for shipments of logs from Canada, in June. These works were so designed that they could form part of the permanent reconstruction. Contracts were placed for the supply of steel sheet piling (which was, fortunately, available for delivery within a month) and for trial borings and soil tests. Contractors were invited to inspect the site during the week commencing March 2nd. The contract was awarded on March 6th and plant began to arrive at the site the following day ; a start was made on the work on March 9th. Details of the permanent work are shown in Figs. 2, 3, and 4.

The first essential was to close the breaches at

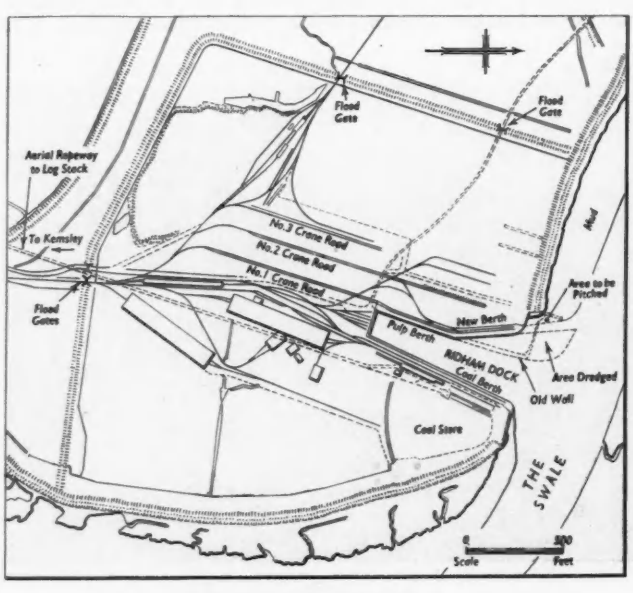


Fig. 1—Plan of site

Fig. 2—Repair work in south part of west quay

either end of the wall, and to dewater the area between it and the emergency clay wall mentioned above: this area thus became available for use by the contractor. Two 350ft rows of steel sheet piling were then driven, one on either side of the wall, the top of the wall was removed to ground level and trenches were cut across the concrete to allow for steel ties connecting the two rows of piling at level 0. The spaces between the piling and the wall were filled with sand, and a timber walkway 6ft wide was cantilevered from the piling on the river side at level +17·5. Railway and crane tracks were placed on the ground behind the wall. The temporary berth, 250ft long, was completed on June 1st, four months after the beginning of the damage, and in good time to receive the first shipment of logs from Canada.

In the meantime, alternative schemes for permanent reconstruction were being prepared and considered. The plan finally adopted provided for the realignment of the north half of the wall so that the new north berth would be inclined at 24 deg. to the line of the old quay and of the repaired south berth, thus widening the entrance to the dock (Fig. 1). This, as already stated, had been reduced to 218ft by the previous movements of the east and west walls and by the consequent repairs, and would have been further decreased if the north part of the west wall had been repaired on the line it had taken up since the flood, allowing less than the requisite margin of safety for ships entering or leaving with other vessels berthed on either side.

The new north berth consists of two lines of steel sheet piling spanned by a concrete deck 47ft wide, which is also supported by reinforced concrete piles, as shown in Fig. 3. The steel piles on both sides are driven to level −38, and the concrete piles 5ft to 10ft deeper. The deck carries rail and crane tracks. A concrete platform 6ft wide was cantilevered from the sheet piling on the water side at level +17·5, so as to join up with the temporary timber walkway which has been provided for the south berth.

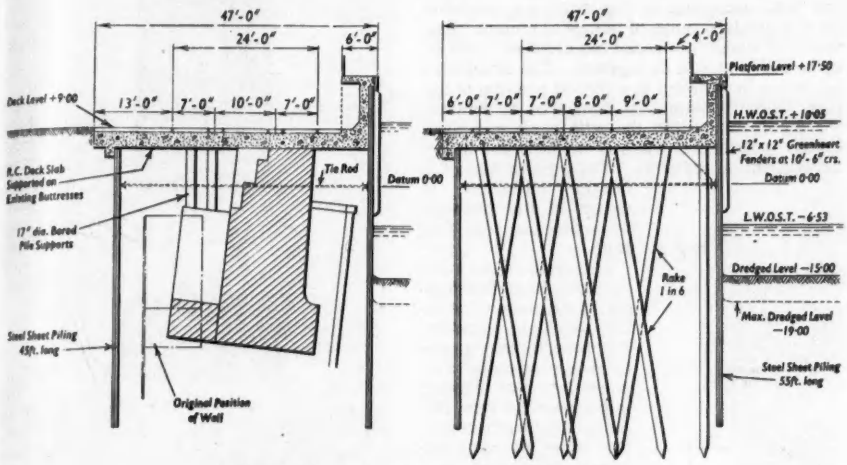


Fig. 3—Reconstruction of west wall—typical sections

The chief problems in construction of the north berth were, first, the forming of a cofferdam at the junction with the south berth and, second, the removal of the mass concrete constituting the north half of the old wall, together with the steel and timber sheet piling. The demolition was carried out by drilling and blasting under water to a depth below −20 over an area extending 250ft from the line of the new berth, and the remainder to a depth below −17. The pieces were lifted by grab. These operations and the actual construction of the new berth were successfully completed and the first ship berthed on December 11, 1954.

The last stage was the completion of the south berth as a permanent structure. This consisted of forming a concrete deck over what remained of the original mass concrete and replacing the timber walkway with a concrete platform, both deck and platform being made continuous with those of the north berth.

The consulting engineers for the work described here, subsequent to the 1951 storm surge, were Sir Alexander Gibb and Partners. The contractor was J. L. Kier and Co., Ltd.

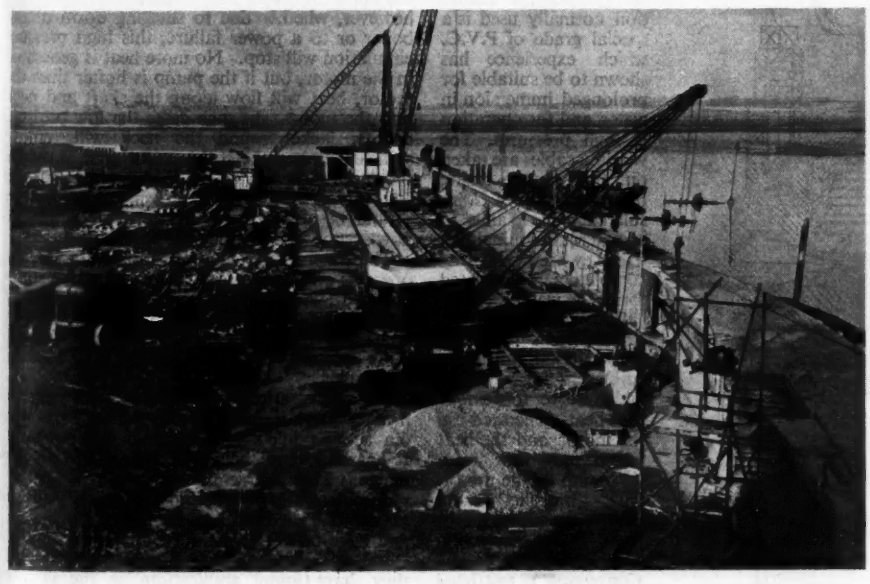
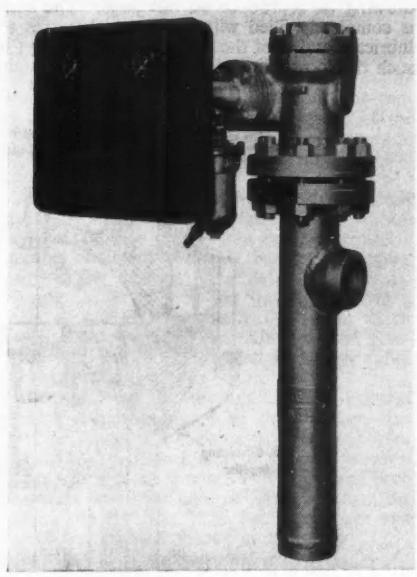


Fig. 4—Reconstructed west quay at entrance of Ridham Dock

Liquid Level Controller

A NUMBER of improvements have been introduced by the Crosby Valve and Engineering Company, Ltd., of Wembley, in the latest model of the Mason-Neilan air-operated displacement liquid level controller/transmitter. This instrument has been used for some years in the oil, chemical and process industries and the improved design now being made retains the same fundamental principles.

In the latest instrument, shown in the accompanying illustration, the pneumatic control mechanism is mounted directly on a cast iron frame bolted to the torque tube housing. The specific gravity scale, which enables the instrument to be set for the density of the liquid to be controlled, has been widened to a range of 0·5 to 1·4 S.G. This will provide for most applications with the one scale.



Air-operated displacement design liquid level controller transmitter

The length of the set point scale has been increased and the method of adjustment simplified; it is also so arranged that a 3 lb to 15 lb per square inch bellows can easily be provided for remotely setting the control point. If required an improved reset or integral action resistance unit can be fitted to a standard proportional controller on site. A smaller torque tube mechanism chamber than hitherto is used, and the dimensions between connection centres conforms with international standards. Slack diaphragms of special materials for sensitivity are fitted in the pilot valve, which incorporates a jewel orifice with a plunger so that the orifice can be cleaned whilst the instrument is in operation.

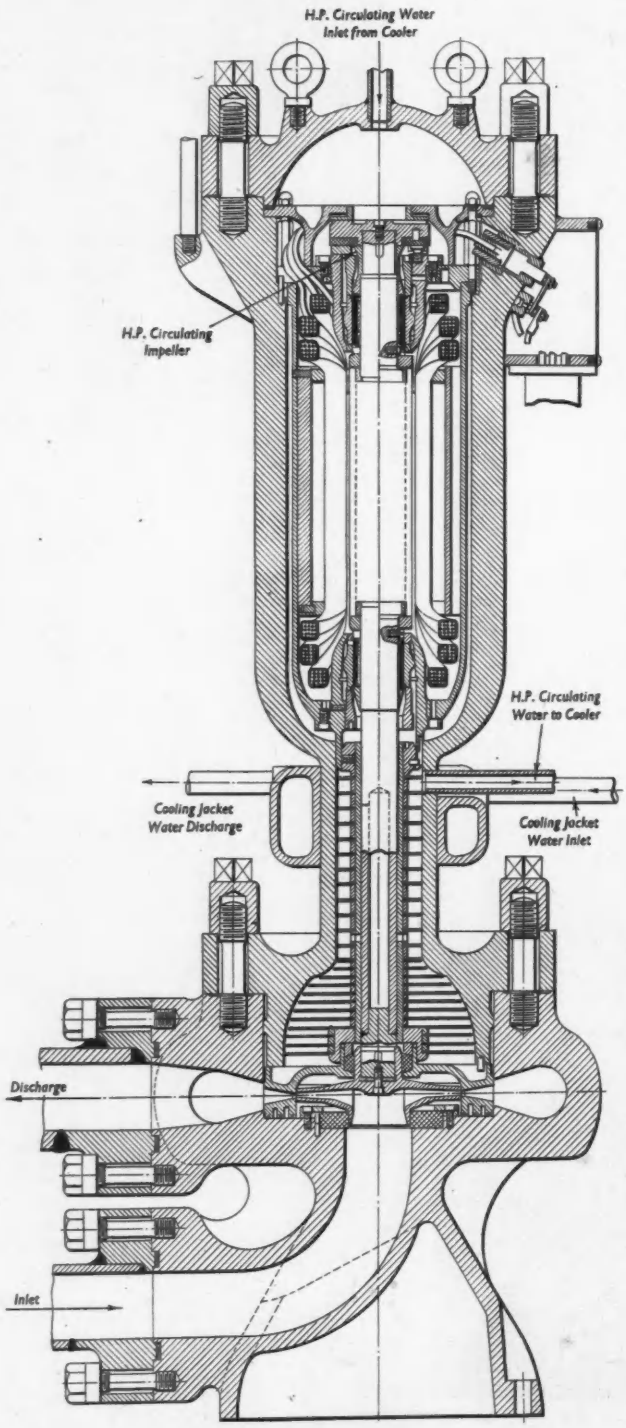
The controller can be supplied for mounting with the displacer either inside or outside a vessel and can be arranged as a proportional controller with or without reset, as a transmitter, as a specific gravity transmitter or controller, or as a combined controller and transmitter.

COKE OVENS AND BY-PRODUCTS PLANT AT MURTON.—It is announced that a contract worth more than £2,000,000 for the construction of a new coke oven and by-product plant at Murton has been awarded to Woodall Duckham Construction Company, Ltd., by the Durham Divisional Coal Board. The board will shortly commence site clearance work and the project is scheduled for completion by September, 1958. The new plant will be an essential part of the board's scheme for a combined mine where coal from Murton and Eppleton collieries, and ultimately from Elemore, will be drawn up the new Hawthorn shaft now in process of sinking. The fifty new ovens will handle 1000 tons of coal a day, all drawn at the combined mine and cleaned at a washery which is to be built nearby. The new coking plant will be capable of producing 250,000 tons of coke yearly as well as supplying 7½ million cubic feet of purified gas daily for the gas grid. By-products will include sulphate of ammonia, tar and more than 1,000,000 gallons of crude benzole annually.

Glandless Circulating Pump

As pressures and temperatures in power plants have risen, troubles have been encountered in gland leakage in circulating pumps, and it has also been necessary to use large volumes of water for stuffing-box cooling purposes. To overcome these difficulties a totally enclosed pump and motor unit in which there are no glands or rotating seals has been developed by Hayward Tyler and Co., Ltd., of Luton. In this boiler circulator the pump and motor are enclosed in a single pressure-tight shell, as can be seen in the drawing we reproduce on this page. The shell is completely filled with water which serves to lubricate and cool the motor, and the design is such that possibility of leakage round the pump shaft is eliminated and there are no glands to be packed.

The circulators are made with a single radial or mixed flow impeller and can be designed for working pressures up to 3000 lb per square inch. Driving motors from a few horsepower up to 250 h.p., according to the duty, are available for the standard range of pumps at present being made, although for special requirements units of up to 2000 h.p. can be supplied. The circulators are normally installed in a vertical position in the pipe system by means of flanges or by welding the pump casing into the pipe work, and their design is such that there is no need for heavy anchorages or pedestals. The arrangement of a typical circulator is shown in the drawing we reproduce on this page.



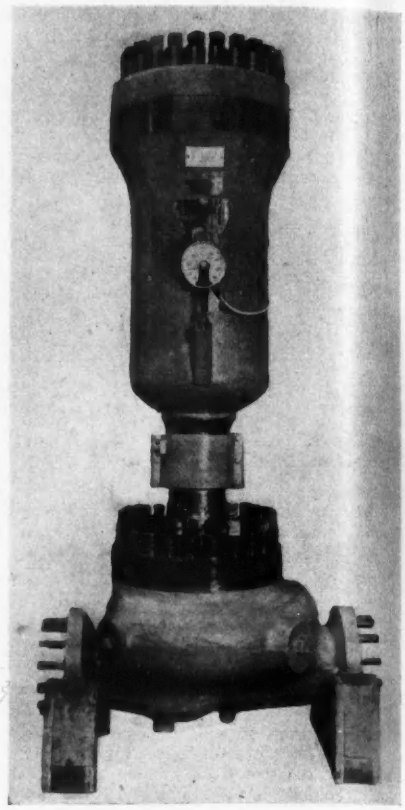
Section through boiler circulating pump

The motor shaft runs in two journal bearings and is extended to carry the overhung impeller. The pressure casing surrounding the motor and pump has two flanged joints, one between the motor and pump casing, the other between the motor casing and pressure cover.

For operation the casing is filled with water at boiler pressure, the only external connections being the pump suction and discharge, the inlet and outlet to a high pressure cooler, and the glands for the power supply. The water in the casing acts as a lubricant for the journal and thrust bearings, all of which, because of the low viscosity of water, are of special design incorporating the use of Michell pads.

A squirrel-cage induction motor is used and no electrical contact with the rotating assembly is therefore necessary. In the stator windings the insulation on each conductor is designed to withstand the full line voltage, and the insulation normally used is a special grade of P.V.C. which experience has shown to be suitable for prolonged immersion in water and for operation at high pressures. The winding cables are taken out through the casing by means of P.V.C. insulated cable glands to an external terminal box and they are in this way completely insulated from the water.

The motor has internal (high pressure) and external (low pressure) cooling systems which serve to remove the heat generated in the motor and the heat which may flow from the pump to the motor. Heat transfer from the pump to the motor may be by convection and by conduction. Convection is restricted by baffles fitted behind the impeller, and conduction is minimised by reducing the cross-sectional area of the casing between the pump and the motor.



52 h.p. circulating pump with two 6in suction inlets and one 6in discharge

For continuous operation, in order to safeguard the insulation of the windings, it is recommended that the temperature of the motor should not exceed 135 deg. Fah. The cooling system is normally designed to keep the motor temperature at 120 deg. Fah., so that there is a considerable margin of safety to allow for falling off in cooler performance. If required, a thermostatically-operated alarm system can be fitted to give warning of any undue rise in temperature.

The circulation in the high pressure system is promoted by an impeller on the top of the rotor shaft and the water in this system removes the heat from the motor and also some of the heat which travels up the shaft and the neck joining the pump to the motor. Once the motor stops, however, whether due to shutting down of the boiler or to a power failure, this high pressure circulation will stop. No more heat is generated in the motor, but if the pump is hotter than the motor, heat will flow along the shaft and neck into the motor. In such cases the low pressure cooling jacket round the neck will remove sufficient heat to keep the motor cool, provided the supply of water to the jackets is not cut off. For this reason the low pressure water supply should be arranged so that it will continue to flow even if there is a power failure.

The water in the high pressure cooling system operates on a closed circuit so that water is not being drawn in continuously from the main boiler circuit. In this way sedimentation in the pipes and motor is kept to a minimum, but, to inhibit the entry of sludge, baffles are fitted behind the impeller.

The illustration above shows one of the firm's 52 h.p. circulators which has two 6in suction inlets and a single 6in discharge. It has an overall height of 7ft 5in and its top flange is 25½in diameter.

Circulators of this design have been made by Hayward Tyler and Co., Ltd., for some years and have been giving satisfactory service on La Mont boilers of various sizes. More recently they have found applications in the field of atomic energy, and units are now being supplied both in this country and overseas.

2500kW Gas Turbo-Alternator

FURTHER details have now been released of the British Thomson-Houston 2500kW gas turbo-alternator sets ordered by Balfour Beatty and Co., Ltd., for the Nairobi South Power Station, Kenya. The first of these sets, Fig. 1, went into service in September, 1954, and the second machine, Fig. 2, has recently completed satisfactory running tests at the Rugby works of the British Thomson-Houston Co., Ltd., and is now being erected on site.

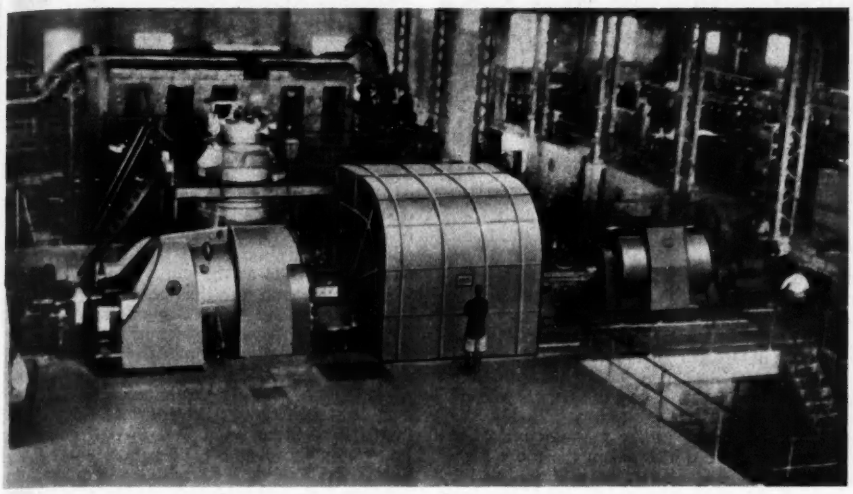


Fig. 1—First of two 2500kW gas turbo-alternators at Nairobi South power station

These sets were designed some years ago and it was decided at that time to incorporate a centrifugal compressor in their design.

Axial compression has now been adopted in the various designs of gas turbines which are now available from the company. This decision makes possible an improved overall thermal efficiency and provides a single-line axial-flow unit without a heat exchanger which very nearly attains the same efficiency as one of the Nairobi sets with a heat exchanger. Moreover, the overall size of an axial-flow unit compared with one incorporating a centrifugal compressor of similar rating is considerably smaller ; in fact, a machine of 5000kW output occupies roughly the same floor area as one of the Nairobi (2500kW) sets.

The company has now standardised on three sizes of gas turbo-alternator sets for power generation, having nominal ratings of 2500kW, 4000kW and 6500kW ; a fourth size of 10,000kW is now being designed. These standard machines are single-shaft sets comprising a turbine driving an axial-flow compressor directly, together with an alternator driven directly or through reducing gears. Two-shaft designs with a free power turbine are also under consideration. Each of the two identical 2500kW gas turbo-alternators for Nairobi South Power Station—operate on the open-cycle system with the compressor coupled in line with the turbine, the alternator being driven through a reduction gearbox from the other end of the compressor shaft.

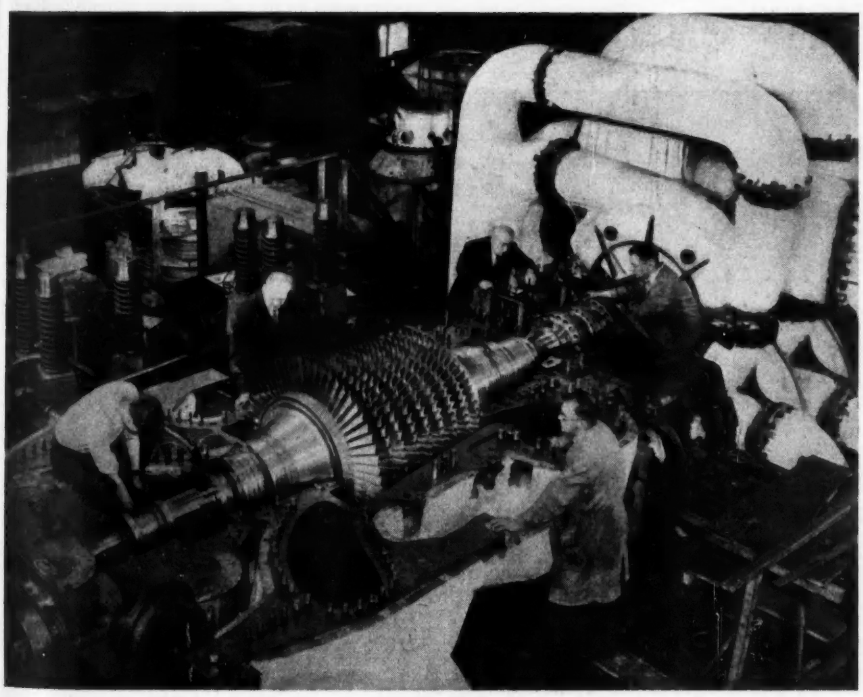


Fig. 2—The second machine in course of erection, showing the turbine rotor in position in the bottom half casing

The gearing gives a speed reduction from the turbine/compressor unit of 3500 r.p.m. to 1500 r.p.m. for driving the salient-pole alternator which has a rated three-phase output of 3125kVA at 0·8 power factor, 10kV, 50 c/s. A gear coupling is used between the compressor shaft and the high-speed pinion of the gearbox.

Compressor.—The compressor is of the four-stage centrifugal radial-flow design with backward-inclined vanes. The impellers are shrunk on and keyed to the shaft and are built up of vanes riveted to the impeller disc and to the shroud plate.

The diffuser system embodies Oerlikon principles and consists of four partial spirals connected to four straight conical diffusers. The four diffusers of each stage are cast integral with the top and bottom half of each casing with fabricated steel pipes connecting the outlet of each diffuser to the inlet passage of the next stage. The compressor has a compression ratio of 4·5 to 1 and a throughput of 70,000 cubic feet per minute.

After compression, the air passes to a heat exchanger sited outside the power station building and then returns to a single combustion chamber mounted vertically beside the turbine casing. The exhaust gases enter the heat exchanger at the bottom and flow through in a single pass at right angles to the tubes, which are mounted horizontally. Air from the compressor flows through the heat exchanger tubes in two passes.

The exchanger is built up of four identical sections mounted on top of one another, this form of construction being adopted in order to facilitate transport and to simplify erection on site. The width is relatively narrow and both sides have doors for ease of access to clean the unit on the gas side. The heat exchanger was manufactured by Babcock and Wilcox, Ltd., to British Thomson-Houston design.

Combustion Chamber (*Fig.* 3).—The bottom part of the combustion chamber is bolted solidly to the bottom half turbine casing but the weight of the chamber is carried on six springs at turbine floor level. Incoming air from the heat exchanger enters at the bottom and passes vertically upwards between the outer shell and the flame tube to the top of the chamber where the air divides into two flows. One of these enters the primary zone with the fuel and is used for combustion while the other flow is used for cooling the products of combustion. The combustion zone is refractory lined and the fuel oil is sprayed into the chamber through two main burners, the fuel flow being controlled by a lance operated from the governor system in the orifice of each burner. The initial starting is accomplished by means of a pilot burner which is fired by spark igniters supplied from high-energy power packs. Observation windows are provided at the top of the combustion chamber so that the flame may be checked.

Turbine.—The turbine is designed for an inlet temperature of 1200 deg. Fah., and is a nine-stage machine running at 3500 r.p.m. It is coupled to the compressor by means of a gear coupling and tension shaft with a Michell thrust bearing incorporated between the compressor and turbine.

A welded construction is used for the turbine rotor which is made up of three forgings in austenitic steel welded together to form the rotor barrel with a stub shaft (also in an austenitic steel) welded on at each end. A similar material is used for the turbine casings as well as for the turbine blading, except in the first stage which is of " Nimonic."

Both ends of the turbine shaft are provided with labyrinth packing glands which are supplied with air at an intermediate point from the compressor exit so that a flow of cooling air is created outwards along the shaft. At the same time, a small quantity of air passes into the turbine and quite apart from assisting in keeping the turbine bearings cooled, this arrangement prevents any leakage of combustion products into the engine-room.

Fuel Supply.—Fuel oil gear pumps deliver the fuel through steam heaters to the combustion chamber at a pressure of 600 lb per square inch gauge.

Governor Gear.—A speed governor regulates the supply of fuel oil to the combustion chamber through an oil-operated servo motor. The governor equipment is mounted between the turbine and compressor and is driven from the main turbine shaft through spur gearing. An extension from the governor shaft is also used to drive the main lubricating oil pump. Oil for the governor servo system is provided by duplicate motor driven Hamworthy gear pumps.

Starting and Barring Motors.—A barring motor rated at 25 h.p. at 975 r.p.m., drives the main turbine shaft through a centrifugal clutch, a train of gears, and an oil-operated clutch. The starting motor with a ten-minute rating of 300 b.h.p. also drives the turbine through a train of gears and the same oil-operated clutch. There is no centrifugal clutch on the starting motor drive.

During the run-up, the barring motor is thrown out of engagement automatically when it is overdriven by the starting motor, but it continues to run until the turbine has reached its self-maintaining speed and overdrives the starting motor. When this happens, the oil-operated clutch is thrown out of engagement and both the barring and starting motors are tripped out.

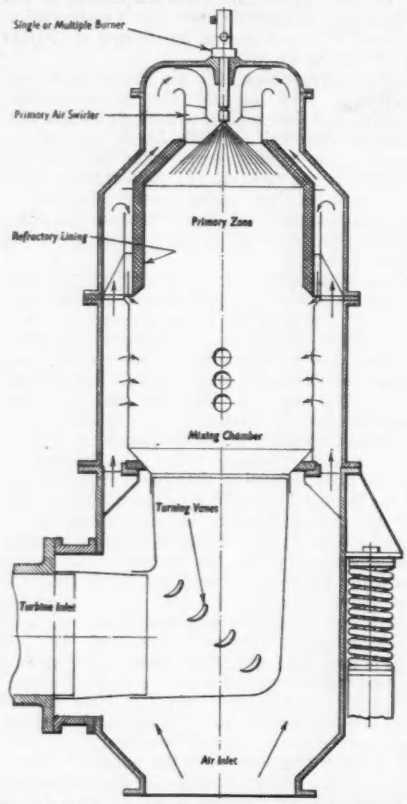


Fig. 3—Section through refractory-lined combustion chamber

Starting Procedure.—Starting the set is comparatively easy. All the auxiliaries are operated from a 415V a.c. supply, taken from the station switchboard, which is fed into a contactor cubicle housing the starting equipment for all the motors associated with the gas turbine.

When the isolators on the cubicle are closed, power is made available for the desk light, fuel flow recorder, the Selsyn equipment which indicates the position of the hand controller for the governor, and the photo-cells which operate when there is a flame in the combustion chamber. The fuel pump and control oil pump are started by a switch on the desk.

For starting, the hand controller on the control desk has to be in the "Oil-recirculation" position allowing fuel oil to be recirculated through all the burners in order to raise the temperature to that required for spraying.

Since the first machine went into service, the set has completed over 2000 hours running on a boiler oil fuel (viscosity 550 seconds Redwood No. 1 at 100 deg. Fah.) supplying part of the requirements of the Nairobi power system mainly during the three months dry period from January to April. No water is necessary for the operation of the set other than a small supply of borehole water for cooling the lubricating oil.

Partly as a result of the success achieved with No. 1 machine, it was possible to complete comprehensive running tests on the second machine in the B.T.H. Rugby works within only nine days of it being handed over to the test engineers. During this period, 126 hours of light and load running were completed on a boiler fuel oil similar to that used in Nairobi; the set was not run on a distillate oil.

Cold-Formed Steel Structures

SINGLE-STOREY storage buildings covering an area of more than 750,000 square feet have recently been erected in the North of England, according to a design which utilises components formed of cold rolling steel strip. The accompanying illustrations give a good idea of this method of construction.

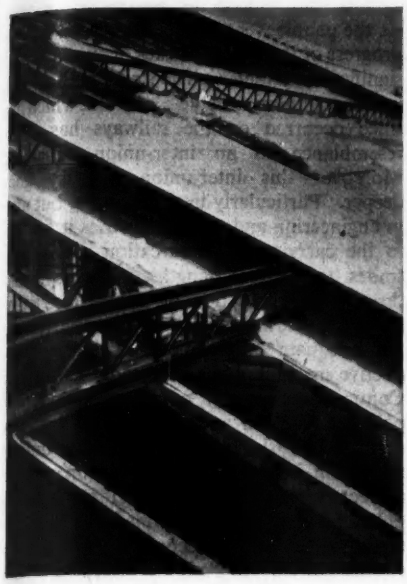
The buildings were designed and manufactured by Metal Sections, Ltd., Oldbury, Birmingham, a subsidiary of Tube Investments, Ltd. The company points out that the same basic principle of construction has been used for a number of years to manufacture skeleton bodies for buses and railcars, and the spread of the method to building has been a natural development. An account of the scope and possibilities of such cold-formed steel structures as developed in the United States, was published in THE ENGINEER of October 12, 1951, page 474.

The present design is based on a three-pin braced portal frame. Each half-frame is delivered to the site in two parts, and a bolted joint is made at the knee. In the manufacture of the frame stiffeners are inserted in the more highly stressed members. The frame is analysed by conventional statical methods, and the basic open-box section is proportioned to take the lightest load experienced. Then stiffeners are added to increase the load-bearing capacity of the other members. The members carrying the heaviest load have the greatest number of stiffeners and the design approximates to the ideal of a structure in which all the members are equally stressed in so far as its primary stress analysis is concerned. The drawing clearly demonstrates this method of design and indicates which members are of the basic section marked "A," and how additional stiffeners are added to the "A" section elsewhere. The internal bracing members of the frame are of a smaller section than the "A" shape, except for three members at the knee. The frame has welded joints and the stiffeners are spot-welded on to the "A" section.

The pin joints at the bases of the main frames are formed in grey iron castings held in the concrete foundations by bolts. The portals span 50ft and have a height of 15ft to the eaves; they are spaced 20ft apart. The main purlins are of lattice construction, again cold-formed from sheet and comprising lipped channel sections forming the upper and lower flanges with tubular cross-bracing members spot-welded between them. Corrugated asbestos roof sheeting is bolted on to the top flanges of the purlins, and a lining providing thermal insulation is carried on the lower flanges. This construction is shown in our second illustration. It has the advantage that the lining board can be fixed from the outside at the same time as the roof sheeting is erected, thus obviating internal scaffolding. The "T"-shaped steel sheeting rails spanning between the purlins support the sides of the insulating boards. These sheeting rails are slotted at intervals, and a small piece of steel is inserted, from underneath, into each slot, so that it can be bent over to form a clip holding the insulating board in position. The illustration shows a clip in position before being bent. The building is completed with corrugated asbestos wall and gable-end cladding, guttering, wind bracing in the end bays, and tie-members, which provide restraint against buckling perpendicular to the plane of each portal. These last bracing members, which are tubular, connect the lower booms of the main frame with the purlins and are shown in the illustration of the completed building. Variants of this basic design, for different spans and distances between the main frames, can be readily provided. In one case a greater span—40ft—between main frames was accommodated by braced main beams, running at ridge and valley, between the main frames. These beams were built up in a very similar manner to the portals themselves and carried secondary beams spanning the slope of the roof.

As the design was considered somewhat novel in character, a full-scale loading test was insisted upon. The heavier structure mentioned in the

Interior of completed building

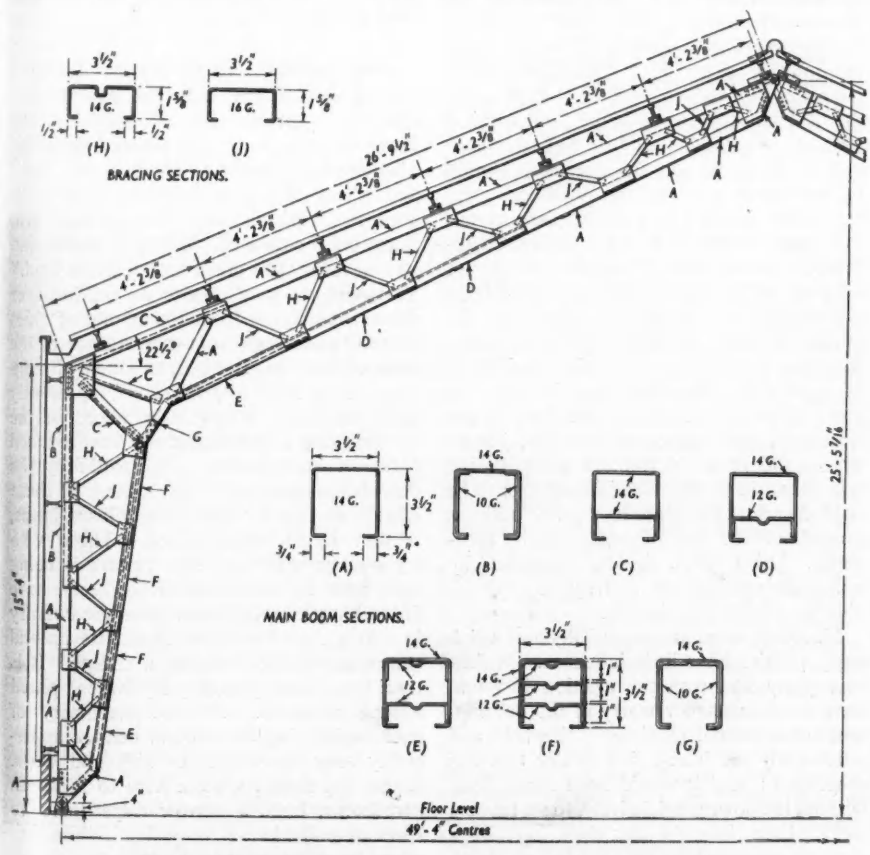


Detail of roof construction showing purlin carrying sheeting rails and insulating board on bottom flange and corrugated asbestos roof sheeting on upper flange

last paragraph was used for the test, and one complete bay was erected, and subjected to a test with overloading and a test to give over-stressing, but was not tested to failure. The maximum load carried was equivalent to a distributed load of 45·82 lb per square foot and an apex load of 1720 lb. The corresponding specified design loads were 25·10 lb and 1120 lb. The structure was subjected to stresses in excess of the corresponding design stresses by about 58 per cent in maximum tension and 74 per cent in maximum compression. The maximum deflection observed (in the centre secondary beam) was nearly 3in. The structure did not yield, but an indication of a probable mode of yielding was given by the appearance of strain lines on the paint at the inner gusset plate of one of the portal knees. It was thought that an irregularity such as a twist in the fabricated form of the half-portal was responsible for a bending action perpendicular to its plane. This induced relatively high compressive stresses in the inner gusset plate, and the further "stress-raiser" effect of the bolt-holes gave rise to the strain line pattern.

Another aspect considered in the present case was that of corrosion resistance, and instead of mild steel "Corten" high-tensile low alloy steel, with a corrosion resistance stated to be at least four or six times that of mild steel, was used.

The makers claim that the cold-rolled structural design which they have developed gives a saving in steel of about 30 per cent over conventional steelwork and a saving in cost of about 10 per cent. Typical costs given per square foot were 6s. 8d. and 9s. 10d., respectively, for the steel structure and the completed building, using mild steel, and 7s. 3d. and 10s. 5d. using the "Corten" steel. Erection time also is short, and the 750,000 square feet of buildings in the contract illustrated will be completed, it is estimated, in a total time of twenty months. This speed of completion is achieved by simplicity in the site erection, repetition in manufacture, and also by the relative availability of coiled strip at a time when steel generally is in rather short supply.



Details of three-pinned portal frame made from cold-formed steel strip

Bronze Alloy and Cast Iron Bars in Long Lengths

One of the difficulties in producing machined components economically in quantities from phosphor bronze and cast iron bar has been that these metals were available only in relatively short cast lengths and generally in the rough cast condition. To meet this need for long bronze and cast iron bars Sheepbridge Alloy Castings Ltd., has for some time been engaged in the development of a technique and equipment suitable for the production of chill cast bars by a continuous casting process. As a result of these investigations a successful design of continuous casting plant was developed and three of the machines have been built and installed at the firm's Sutton-in-Ashfield foundry. These machines are now producing high quality

Experimental vertical continuous casting machine for the production of bronze alloy and cast iron bars in long lengths

phosphor bronze and plain or nickel-chromium alloy cast iron rods in standard lengths of 10ft to 15ft and from ¾in to 3in diameter. Longer lengths can be made.

The continuous cast bronze rod is known under the trade name of "Solicast" and is stated by the makers to be completely free from cold laps, gas holes and foreign inclusions. The typical properties of a bar made to B.S.S. 1400 P.B.I. (2B8) are quoted as follows: ultimate tensile strength 18 to 22 tons, elongation 4 to 10 per cent, and Brinell hardness 105 to 127. A further advantage is that the bars can be supplied finish machined to within 0·002in of the specified diameter.

One of the firm's experimental vertical continuous casting machines is illustrated on this page. It has a reservoir or holding furnace to which molten metal is supplied at the required intervals from a larger melting furnace. From the reservoir the metal flows through a spigot at a controlled rate into a long graphite die of the required bar diameter. At the furnace end the die is heated to keep the metal in a molten state and a cooling water jacket is formed round the remainder of its length. The cooling rate of the metal in the die is graduated and carefully controlled in accordance with the structure and composition of the metal alloy. As the metal sets and forms a bar it is drawn out of the die at preset intervals, and the length of the drawing stroke and time interval are controlled by automatic means, which can be adjusted to suit the size of the bar and the composition of the metal.

When casting bronze rods the machines produce from 40ft per hour of 3in diameter bar to 160ft per hour of 1¼in diameter bar. With cast iron the production speeds are slightly lower and vary from 30ft per hour of 3in bar to 120ft per hour of 1in bar. Of the three machines at present installed one is continuously engaged in producing bronze and the other cast iron bars and the third one is used for experimental purposes and research. Two further machines now in course of construction will double the output of the existing plant.

This new continuous casting plant is installed in a large new extension, which was added to the Sutton-in-Ashfield foundry some eighteen months ago to make possible an increase in the production of special heat and corrosion resisting alloy castings in which the firm specialises. The extension covers an area of some 350,000 square feet, about half of which is occupied by the foundry, and the remainder by a well equipped machine shop where the castings are rough or finished machined according to purchasers requirements. A new bar turning machine was recently installed in this shop for finishing the continuous cast bars to the close limits specified.

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THE ELECTION AND THE STRIKES

This is a technical journal. Its job is to report on and sometimes to comment upon only those matters that may have an influence on technical advancement. The party political "game" is not its affair. It is prepared, at need, to praise or criticise the actions of a Government regardless of its political conception. Yet, even so, we cannot help feeling that a majority amongst engineers will have sighed in some relief when last Friday morning's news from the constituencies indicated that the Conservatives would be returned to power with an increased majority. It is true that the work of many engineers is not greatly affected by the complexion of the Government ; for any Government to-day would take any action open to it to retain full employment and to encourage output. It is equally true that within those matters that are their concern Governments have in reality little room nowadays for manœuvre. In face for example of a really serious ecomonic crisis the actions of Mr. Gaitskell would be unlikely to differ greatly from those of Mr. Butler ; neither party would be likely to devote more than the other to expenditure on road development or industrial research ; and, in practice, it is improbable that if returned to power the Socialists would have done any more for Lancashire's textile industry than the Conservatives are prepared to do. Even the very real difference in philosophy between the parties makes less difference than might be expected. For although the Conservatives believe the job of a Government is to administer, to produce a climate which will encourage individual industrial expansion, and to hold the ring as a referee rather than to take part industrially itself, and though the Socialists think industry should be more directly controlled by the Government and that Government departments ought to undertake certain industrial operations, as by bulk buying, the consequences of this difference of approach are not profound for engineers. For whatever the Government's philosophy much the same people must do much the same jobs because they are the only people who have the skill and the experience to do them ! The reason for our relief in the Conservative victory lies therefore not in a party preference but in a conviction that this is not a time for further experiments in socialisation. Whether or not, for example, it would eventually be better for the country to re-nationalise the steel industry is a point open for discussion (though we think not !). But it seems definite to us that at the moment it should be left alone to carry on with the great expansion and modernisation plans it has in hand. Certainly it is better that engineering firms with tied foundries should not be plagued by fears that under a Socialist Government nationalisation might be extended to them. Industry will be the more confident in planning expansion if relieved of fears that under socialism it might be more highly taxed. In fact we feel—as the electorate, too, seems to have felt, judged by the fall in the percentage going to the poll—that there are no serious wrongs to be righted and that the country's prime business now should be that of expanding its prosperity. Five years hence, enriched by politically undisturbed activity, it may be able to afford experiments.

Moreover, there are some affairs over which party politics have little influence. Whichever party had won the election it would have found cause for worry in the development of industrial relations in this land and particularly the inter-union rivalry that has developed : and it would have found itself without the power, legislatively, to set matters right. Ever since the war there have been sporadic unofficial strikes directed as much against the unions as against employers. As the people went to the polls there were in progress or threatened strikes of an even more significant character. The strike in the docks is an inter-union struggle ; and that which has since occurred on the railways has some resemblance to an inter-union squabble. Moreover this inter-union jealousy goes deeper. Particularly in shipbuilding but also in engineering and other industries it has led to the carrying of demarcation as between trades to extreme lengths. Thereby, and through the adoption of other restrictive practices, born of fears of unemployment, the adequate employment of highly productive machinery has been sadly hampered. Continued prosperity, unimperilled by party political conflicts and undisturbed by controversial legislation may permit the unions and their followers to reflect upon and to correct the folly of perpetuating into the future policies that were only justified originally by conditions which, if economists keep their senses, are very unlikely to recur. For the prosperity of this country in the future as much will depend upon the wisdom of the union leaders as upon the colour of the Government. Unfortunately, that wisdom seems to be notably absent amongst those who have precipitated a strike on the railways and caused the proclamation of a state of emergency. Engineers must regard with sympathy the desires of skilled men to maintain "differentials" : but not when they press the matter so immoderately as to threaten the general prosperity. The affair could have been, and will eventually have to be, settled by negotiation. The union, not the British Transport Commission, proved adamant. It is this kind of problem in industrial relations for the study and solution of which a period of relative party political peace is so much to be desired.

OUR GREEN AND PLEASANT LAND

As April slips into May and May, in turn, into June, the thoughts of engineers, like those of other men, turn towards holidays. They look forward to days when the cities and towns in which they dwell will have been left behind. For a space they will shake off the dust of offices and works and go out into "this green and pleasant land." Yet wherever they choose to go, however remote it may be from the smoke of cities they will not escape from the evidence of the work of their hands. For, as Dudley Stamp remarks in *Man and the Land*, a recently published book, "very little indeed of the scenery, even in the wildest and least touched parts of our islands, can truthfully be described as natural." The scenery of these islands, as that of most long-civilised lands, is very largely man-created. Those who cry out, as many do, that Nature is being desecrated by the works of engineers, have failed, therefore, to observe that the country in which they live is no nearer its natural state than civilised man to a savage. It is true that man proves puny when pitted against contours. All the machinery of civil engineering contractors cannot appreciably alter the shapes of hills and dales. It can but flatten a piece here to make an aerodrome, build a narrow ridge there to form an embankment, or gash a hillside elsewhere to make a quarry. But setting con-

tours aside, the birds, the beasts, the foliage and the flowers to be found in Britain are those that man has encouraged to flourish or refrained from persecuting, not those that would be there had everything been left to Nature.

The countryside, like man himself, is evolving. Already the virtual disappearance of the horse and the coming of tractors and agricultural machinery is changing the face of England. The chequerboard of small fields is being broken up, the hedgerows are coming down. For machines demand more space for the full development of their capabilities. New times call for new crops. The green of sugar-beet tops covers land once laid down to corn, and the ancient windmill is replaced by the beet factory. Has there been outraged protest? Yet such changes promise to have effects upon England's scenery, and that of Wales and Scotland, too, far more profound than the localised building of a dam or the running of a power cable up a valley ! Nor in that evolution that is constantly progressing can the wants of man be neglected. In the past tangled forests were cleared to make room for cultivation and pasture ; tracks, and then roads, and then great highways, reached into hitherto remote valleys ; marshes were drained and brought into production ; windmills were erected to grind corn or pump water ; rivers were tamed to operate water-mills. Now outlying farms are crying out for the benefits of electric heat, power and light, and for speedy transport ; and if they do not come to them—and come at an economic price—the drift of men from the land to the cities may be accelerated. It is not untamed Nature that those who resist the encroachments of engineers endeavour to pursue but merely the *status quo*! And what strange beings humans are ! Objection is almost invariably raised to any engineering project in the countryside whether it be to a hydro-electric works, a new bridge, electric cables, a road, or the siting of a quarry. Yet in looking around it is found that, once built, many of those works become so familiar that as much opposition is aroused by any project for their abandonment ! Two hundred years ago landowners objected to the building of canals, desecrating the countryside. To-day, there is an outcry because the British Transport Commission would abandon some of them. Think, too, of the protests that come in when any railway branch is to be closed down and compare it with the anguished outcries that the building of railways brought forth ! How melancholy we feel at the sight of a water-mill falling into decay, its wheel silent and the timbers of the lasher rotting. Yet in its day, no doubt, that intrusion of machinery into a horse-propelled countryside, that interference with the natural flow of the river's waters, aroused intense opposition amongst country dwellers.

Of course, engineers and industrialists can do damage to the countryside. There are innumerable instances of badly sited, inconsiderately operated works, uncounted examples where a desire for economy has been allowed to overweigh amenity. Not every bridge or dam or reservoir adorns the countryside, nor are all schemes for new structures perfect as first proposed. Engineers, industrialists and public authorities are only human. However much they may strive to give due weight to all considerations, their projects will inevitably be so designed as to suit them best. We see much good, therefore, in those who criticise neither to destroy nor to prevent, but to bring about improvement, and the fact that the critics may be self-interested is beside the point, for so, too, are those who conceived the project. It is, however, less easy to understand those who speak solely of desecration, disinterested though their motives are. For to them, in opposition to a continuing evolution, all the works of engineers appear to be anathema. Indeed, we feel that by confining their activities to the countryside, whose beauties engineers are as much concerned to respect as they, they waste energies that could more usefully be employed did they but look at cities. For how much has been, and continues to be, done in cities that is deplorable ! How much there is to be done to rid them of smoke and dirt ! What a state we have, inadvertently and unintentionally, allowed rivers and streams in industrial areas to fall into ! There must be evolution in the countryside. But we do not believe it will come to much harm by the work of modern engineers. To cure the ills of cities will take a century or more. " However much," in Dudley Stamp's words, " we may enjoy a particular phase of scenic evolution it is not a conversation piece to be framed and hung upon the walls of a museum or art gallery. It is alive, and our task is so to direct its growth that we create beauty, not destroy it."

Literature

Fifty Years of Western Express Running. By O. S. Nock. Bristol : Edward Everard, Ltd., 38, Broad Street. Price 25s.

THOUGH marked attention is now being given to other forms of motive power on the railways, not only British lines but over the world in general, it is probably true to say that, whatever the future may hold in store, steam locomotive performance will, for some time to come, be a subject of practical importance ; moreover, the history of events leading to present standards of everyday running is, in itself, a matter of never failing interest. For these reasons alone, this new book, by a well-known writer, sustained by a boundless enthusiasm for his subject, will doubtless have a wide appeal, the more so on account of the excellent manner in which the subject matter has been presented by the publishers, which leaves nothing to be desired. With a text extending over 350 pages, divided into ten chapters, the author sets out in an interesting manner particulars of numerous examples relating to the performance of many types of Great Western locomotives extending over the last fifty years. Thus we are told, and in some instances re-told, of the exploits of Dean's " Single Wheelers," so much in evidence during the early years of the present century, followed by the road performance of more recent designs due to Churchward, Collett and, last of all, F. W. Hawksworth, the last C.M.E. of the time-honoured old Great Western. In addition to providing descriptions of notable locomotive runs, supplemented by tabulated " logs," the historic development of the varied types of engines concerned receives attention.

Early in his pages the author refers to W. Dean's 4–2–2 engines as being built between 1891 and 1899. It should, however, be remembered that the 4–2–2 " singles " did not actually appear till 1894. The original engines of 1891 had a single pair of leading wheels ; that is to say, they were of the 2–2–2 type and, as thus built, had cylinders no less than 20in diameter. As the result of a derailment at the Box Tunnel, said to be caused by excessive lateral play allowed the leading axle, the class was rebuilt with a leading bogie and with cylinders reduced in diameter to 19in. It may be added that, when introduced in 1891, these engines were constructed to suit the old broad gauge, but in such a manner that they could be readily adapted for the standard narrow gauge.

Referring now to Dean's 4–4–0 express engines of the " Armstrong " class, these were not really a new design in the generally accepted sense of the word, but were rebuilds, two being evolved from Dean's two tandem compounds, engines Nos. 7 and 8, and the remaining two from 2–4–0 type B.G. engines. As compounds, Nos. 7 and 8 were failures and the resulting " Armstrongs" were not, it is understood, of much account.

Later in the first chapter, the remarkable locomotive exploits with the " Ocean Mails " during 1904, between Plymouth and Paddington, are chronicled, including a discussion of the records set up by the " City of Truro," Churchward's 4–4–0 engine, and the Dean 4–2–2, " Duke of Connaught," No. 3065. Full details of the run from Plymouth to London of May 9, 1904, were given by C. Rous-Marten in THE ENGINEER of May 20 and June 10, 1904.

It may be recalled that the engine " City of Truro " was credited with a speed of 102 m.p.h. when descending the Wellington Bank. Later, a series of articles from the same pen appeared in THE ENGINEER under the title of " Great Western Locomotives and their Recent Work." These, together with a supplement dealing with G.W. locomotives published with THE ENGINEER of December 16, 1910, provide an excellent historical review of Swindon locomotive practice over many years. The supplement in particular contained diagrams of many of the locomotives referred to in the book under notice.

One of the more interesting events in G. J. Churchward's locomotive practice is seen in the introduction of the compound 4–4–2 four-cylinder engine, " La France," of 1903, followed in 1905 by two further engines of the same general description but larger. These compounds, named " President " and " Alliance," were described as being of the " Orleans " type, being similar to the 4–4–2 four cylinder compounds at that time in use on the Paris-Orleans Railway. As to the working of these three compounds, the results have always been shrouded in mystery and the author has little to say of them except to make the astonishing statement that no dynamometer records of their performance can be found at Swindon. On the other hand, records in the form of Pull-Speed characteristics relating to Swindon-built locomotives are largely quoted, one of which is that appertaining to the 4–6–0 engine " Albion," No. 171, as illustrated in THE ENGINEER of March 23, 1906.

Interesting information concerning the relative performance, as disclosed by official trials, between 4–6–0 and 4–4–2 type locomotives is noteworthy as indicating how engines of equal potential power and differing only in the weight on the coupled wheels compare. The 4–4–2 engines seem to have performed well and for this reason

would seem to explain why Churchward took some time to decide which of the two types to adopt for general service requirements.

Passing on now to later times, C. B. Collett's " Castle " class 4–6–0 engines are given, as would be expected, much attention. At the World Power Conference of 1924, particulars were given of tests made with one of these engines, resulting in a coal rate of 2·83 lb per drawbar horsepower per hour, stated to have caused " some consternation." Certainly the figure is low but the same cannot be said of the calorific value of the fuel used. Herein lies the explanation. Assuming, as the author states, coal consumption is in direct ratio to the calorific value of the fuel, then, with a fuel of, say, 12,600 B.Th.U. per pound, equal to Blidworth coal used for the B.R. engine tests, as against 14,780 B.Th.U., as used in the " Castle " trials and taking these values as being " as fired " in each instance, the " Castle " consumption with the former fuel would have been 3·3 lb per drawbar horsepower hour, with the " consternation " effect in an inverse ratio to the coal rates. Referring to the very complete information given regarding the performance of these famous " Castle " class engines, the author is to be commended for the way in which his facts have been presented, and the same may equally well be said of his subsequent references to the " King " class locomotives, both during specific official tests and everyday working on the line. Regarding road performances, the " Logs " presented are well and carefully compiled from a mass of data collected from different sources which no doubt the author considers reliable.

In the concluding chapter, entitled " The Western in a New Age," an account is given of special trial runs between Paddington and Bristol on April 30th last year, preparatory to the inauguration of the " Bristolian " fast train, booked to make the run in one and three-quarter hours without a stop. The author travelled with the train in the dynamometer car, which was made up of eight vehicles, the tare weight being given as 253 tons. On the " Down " journey, 117·9 miles took 99 min 19 sec and the " Up " journey, given as being 116 miles, was run in 95 min 35 sec. These are the actual journey times without any allowance for " slow downs " due to permanent way repairs. The engine used was one of the " King " class, No. 6003. As these locomotives have a total working order weight of 135·7 tons, the ratio of the locomotive weight to that of the train would be 1 : 1·88. In view of the fact that a dynamometer car was available, it would have added to the interest in this trial if the mean powers developed on the drawbar could have been given.

An outstanding feature of the book is, as already indicated, the large amount of official information relating to tests made on the line with successive types of Swindon-built engines in use over the last half-century. The assembling of this wealth of information gleaned from, in many cases, a scrutiny of dynamometer car Pull-Speed charts has entailed a large amount of work. This should be fully appreciated, as should also the author's enthusiasm for the Great Western Railway and its locomotives. Taking it in its entirety, this is without doubt an excellent record of locomotive performance on the Great Western. An informative text is well-supported by a collection of excellent photographic views of trains in motion and also locomotives of different classes, together with diagram drawings, which are very well reproduced. As an aid to a better understanding of the many " logs " of notable runs, the novel plan of providing a series of well-prepared gradient sections of the Great Western line are included. An adequate index is also included, always an advantage, especially in the case of a book which may be largely used for reference.

Welding for Engineers. By H. UDIN, E. R. FUNK and J. WULFF. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 60s.

THE title of this excellent American textbook may be misleading to prospective readers in this country, where customarily a work under this title would be expected to give a conventional description of the various welding processes, some elementary metallurgical explanation of the weldability of metals and alloys and a considerable amount of practical advice on workshop procedure. This is not simply another general work of this kind, but is a serious effort to present welding engineering as a science in its own right, and to help it pass, in the authors' own words, from empiricism to analysis. The authors are associated with the Massachusetts Institute of Technology and the work is in fact based on a course offered to both under-graduate and post-graduate students in the Metallurgy Department of the School of Engineering. The treatment is for the most part fundamental, using principles from physics, mathematics and metallurgy to develop the subject, but the relationships of these principles to the more familiar aspects of welding are clearly traced.

The arrangement of the subject matter at first appears untidy and even random until it is realised that it follows principles involved, building up from the simpler ones to the more complex. The arrangement is not based on the practical relationships of the welding processes to each other, nor does the space devoted conform to their relative industrial importance. Thus, under the heading " Consumable Electrode Processes " one finds, in order, the shielded inert gas consumable electrode process, bare wire arc welding, covered electrode welding, submerged melt welding and stud welding. Again, as much space is devoted to the mathematical aspects of capillary action and surface tensional forces in brazing as to the whole subject of covered electrodes.

The book is nevertheless well written and interesting to read and can be recommended to all who have more than a superficial knowledge of and interest in the subject.

Strength and Resistance of Metals. By JOHN M. LESSELLS. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 80s.

THE aim of this book is to provide design engineers and senior students with information about the behaviour of metals under stress. Such information is essential before theoretically based analytical methods can be applied with confidence to practical problems. Although reference is made to advanced theory, the subject matter of most of the text involves only the use of simple formulæ in mechanics. Starting with an account of the tensile test, the author proceeds to discuss overstrain, cold work and residual stress, creep, hardness, impact, fatigue, strain hysteresis and mechanical wear. The way in which test data may be utilised by the designer is indicated. The importance of hardness tests in the control of materials is emphasised. The notched-bar impact test is clearly shown to be of considerable significance in connection with the behaviour of certain kinds of engineering structure, which, though ductile as judged by tensile tests, may fail in a brittle manner.

As fatigue accounts for a large proportion of engineering failures, and as Professor Lessells has himself made outstanding contributions to this subject, it is not surprising that about one-third of the book is devoted to various aspects of fatigue and the controlling factors which influence endurance. Some actual fatigue failures are described in detail. In these sections prominence is given to the work of Dr. H. J. Gough and his associates at the N.P.L. No reader can have cause to complain that in any part of the book British researches have been neglected, though in one or two cases recognition of priority is perhaps inadequate. For example, it is stated that developments in the United States indicated the value of molybdenum in inhibiting temper brittleness, but surely the British " Vibrac " steel, introduced for that reason in 1921, antedated similar American products by several years. The last chapter contains a brief account of the more important theories of strength, and the various influences which govern the choice of safety factors for proper working-stress calculation are described. Finally, the serious student will find, in the twenty-eight pages of problems, a means of ascertaining whether a mastery of the text has been achieved.

Throughout the book, sufficient metallurgical information has been incorporated to make the reader appreciate the vital connection between metallurgy and mechanical engineering. The variety of the orginal publications referred to is evidence of the truly international character of the author's survey of the literature, resulting in an impartial and well-balanced presentation of the subject. At the same time, Professor Lessells's long experience in teaching, research and practical engineering has given an authoritative quality to the important sections, which appear at intervals in the text, on the significance of various properties or tests to the engineer. There are many factors which make this a notable book and one which should prove to be of great value to all concerned with the mechanical behaviour of metals.

Books Received

Iron Moulding for Apprentices. By F. D. Roper. London : Ernest Benn, Ltd., Bouverie House, Fleet Street, E.C.4. Price 15s.

Soldering and Brazing. By A. R. Turpin. London : Percival Marshall and Co., Ltd., 23, Great Queen Street, W.C.2. Price 5s.

Plant and Process Ventilation. By W. C. L. Hemeon. London : Bailey Brothers and Swinfen, Ltd., 46, St. Giles High Street, W.C.2. Price 76s. 6d.

Fishing Boats of the World. Edited by Jan-Olaf Traung. London : Arthur J. Heighway Publications, Ltd., Ludgate House, 107, Fleet Street, E.C.4. Price 90s.

Vibration Problems in Engineering. Third edition. By S. Timoshenko and D. H. Young. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 65s.

Handbook of Standard Time Data for Machine Shops. By A. A. Hadden and V. K. Genger. London: Thames and Hudson, Ltd., 244, High Holborn, W.C.1. Price 63s.

Applied X-Rays. Fourth edition. By G. L. Clark. London : McGraw-Hill Publishing Company, Ltd., McGraw-Hill House, 95, Farringdon Street, E.C.4. Price 89s. 6d.

The Chain Tester's Handbook. By C. H. A. McCaully. Published for the Chain Tester's Association of Great Britain by Rollprint, Ltd., Rollprint House, 29, Hatton Wall, London, E.C.1. Price 25s.

Third Report of the Ingot Moulds Sub-Committee. Iron and Steel Institute Special Report, No. 52. London : Iron and Steel Institute, 4, Grosvenor Gardens, S.W.1. Price, members 15s., non-members 25s.

Engineering Dimensional Metrology : Proceedings of a Symposium Held at the National Physical Laboratory on October 21, 22, 23 and 24, 1953. London : Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 45s. for two volumes.

Railway Traction by Single-Phase Current at Industrial Frequency

No. II—(*Continued from page* 748, *May 27th*)

A convention on railway electrification at 50 c/s, single phase, was held by the S.N.C.F. at Lille from May 11th to 14th. Recent progress in this system of electrification as revealed at this convention, with particular reference to the Valenciennes-Thionville line, is described here. Last week's article was concerned with questions of power supply and fixed installations. The four designs of locomotive (two C_0-C_0, intended for heavy freight traffic, and two B_0-B_0 for mixed traffic) are briefly described below.

As stated in our issue of January 14, 1955 (page 61), French Railways have adopted a 25kV, 50 c/s, single-phase system for the electrification in stages of the main line from Lille to Thionville, Metz, Strasbourg and Bâle. Work on the first stage of this scheme —that between Valenciennes, Charleville and Thionville—is well advanced, as we saw during the recent S.N.C.F. convention at Lille, and is due to be completed at the end of this year. The whole scheme is scheduled for completion by 1957.

A typical section of this scheme is the Valenciennes-Thionville line, which is characterised by prolonged gradients of 1 in 100 and a maximum of 1 in 87, over which much of the traffic consists of very heavy ore and coal trains. Over the system as a whole, however, the traffic is more mixed and includes a proportion of passenger and goods trains. To meet these diverse requirements the system is being equipped with two main classes of locomotive : the first are C_0-C_0 locomotives, which weigh about 120 tons and are designed to haul goods trains of 1800 metric tons at a maximum speed of about 37 m.p.h. on gradients of 1 in 100 ; the second are B_0-B_0 locomotives, which weigh about 80 tons and are designed for mixed passenger and goods working at speeds up to 75 m.p.h. In each class of locomotive there are two distinct kinds of electrical equipment. Of the C_0-C_0 locomotives the great majority are equipped with synchronous a.c./d.c. rotary converter sets and d.c. motors ; the remainder are driven by three-phase motors fed at variable frequency by single-phase/three-phase converters.

Some of the B_0-B_0 locomotives are powered by single-phase, 50 c/s commutator motors and the remainder by d.c. motors fed through ignitrons.

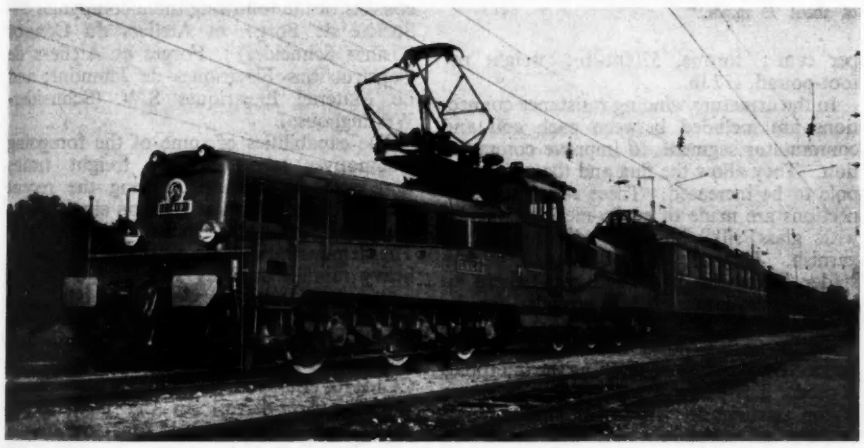

Fig. 4—Locomotive CC 14101 hauling a mineral train of 1800 metric tons. Note the recording car immediately behind the locomotive

As far as possible the general arrangement and the mechanical design of the locomotives are standardised. All four types of locomotive have a single driving cab (Figs. 4 and 5) with a consequent saving, compared with a twin-cab layout, of about 8 per cent in capital cost, as a result of economy in electrical and brake controls, pipework, doors and fittings. In each case the superstructure consists essentially of a flat underframe carrying a prefabricated cab and detachable hoods, which give access to all the electrical equipment. Wind tunnel tests indicate only a slight increase in wind resistance through sacrificing the streamlining that is possible with a conventional twin-cab design. Standardisation is to be found in many common items of equipment, such as roof gear pantographs, circuit breakers, motor-driven compressors, main and auxiliary contactors, relays, heating systems, electro-pneumatic valves, and fuses. All auxiliaries are driven by 380V three-phase motors fed by a standard Arno converter unit.

C_0-C_0 Locomotives

On both kinds of C_0-C_0 locomotive standardisation to a considerable extent is achieved in the design of the mechanical parts, such as the bogie (excluding the wheel sets and gear casings), the underframes and the ends of the motor housings.

The superstructure is carried on each bogie by means of two rigid longitudinally-spaced supports (the same system as was employed in the C_0-C_0 direct-current express locomotives built by Alsthom for the S.N.C.F.), an arrangement which provides adhesion qualities as good as those given by six axles in a single rigid frame.[1] Each motor, which is small, is rigidly secured at its driving end to a gearbox containing double-reduction gears. The motor is nose suspended on the bogie transom, while the gearbox is hung from the axle by means of suspension bearings. The brake gear is designed to act on the wheels of each bogie by means of a single brake shoe for each wheel.

The underframe consists of main side frames of thick plate welded to a box girder frame comprising all the necessary intermediate cross pieces. The ends of the underframe are arranged as footplates, to give access to the hood and to the headlights and tail lamps.

The driving cab, of 4mm steel plate, is assembled from shaped or pressed members welded together ; the roof has a large opening through which the driving control desk can be withdrawn or replaced, and the closure plate carries the circuit breaker and the earthing device. Access to the cab is gained from either side of the locomotive through a hinged door which opens inwards.

The bogie frames are welded and consist of side members made from 50mm steel plate, cross braced.

The superstructure is supported on each bogie by two pivots, each comprising an elastic cone on the major axis ; one pivot can move transversely to allow relative lateral movement between the superstructure and the bogies. Stability of the superstructure is ensured by two helical spring stabilisers per bogie. The underframe rests on the axleboxes through leaf springs mounted on the boxes, and the three suspensions on each side of the bogie are linked by equalising bars, a rubber stud being provided at the end of each spring. The axles have outboard bearings and the axleboxes are connected to the underframe by links with rubber-bushed joints, which are easily dismantled.

Of the C_0-C_0 locomotives a series of 102 are being supplied by Alsthom. Each of these locomotives weighs 125 metric tons, including 7 tons ballast and is driven by six d.c. double-reduction-geared traction motors giving a continuous rating of 2500 h.p. at the wheel rims at 18·2. Direct-current supply for the motors is derived from two generators driven by a 1500 r.p.m. single-phase synchronous motor which is fed from the pantograph through the main circuit breaker and a step-down transformer. Each traction motor is compound wound ; besides the series field there is a separately excited field which is used, during motoring, to give an anti-shunt characteristic and, during regenerative braking to provide excitation of the motors.

Field control by the " anti-shunt " system is carried out progressively as the voltage increases and, by careful selection of the excitation, the locomotive can be operated at nearly constant power output over a wide speed range. The power factor of the synchronous set approximates closely to unity. By employing slight permanent over-excitation the inductive volt drop in the catenaries can be counteracted, and the pantograph voltage kept nearly constant. A locomotive of this series (CC14101) is shown in Fig. 4 hauling a mineral train of 1800 metric tons, with a dynamometer recording car immediately behind the locomotive.

The second kind of C_0-C_0 locomotive is being supplied by the Oerlikon Engineering Company. It is equipped with six three-phase quirrel-cage induction motors which are fed, at variable voltage and frequency, by phase- and frequency-converters, and the continuous power rating is given as 3590 h.p. at 24 m.p.h.[1] Power for the three-phase motors is derived from a converter set consisting of a synchronous motor, a six-pole rotary phase converter and an eight-pole frequency converter with a speed range

of 750 r.p.m. to +1280 r.p.m., which converts the single-phase 50 c/s current into three-phase current with a frequency ranging from 0 to 135 c/s and a voltage varying progressively from 0 to 1300V. This equipment is arranged to form two sets : first a phase converter coupled to a d.c. generator and, second, a frequency converter coupled to a d.c. motor. The d.c. generator is electrically connected to the d.c. motor which is thus supplied at variable voltage, whereby the frequency converter is driven at a variable speed. The frequency converter therefore supplies the three-phase squirrel cage traction motors at variable frequency.

Fig. 5—Mixed traffic locomotive BB 12001 hauling a freight train of 1200 metric tons. This locomotive is equipped with ignitrons and four d.c. traction motors. It weighs 80 tons and is designed for a maximum speed of about 75 m.p.h.

Starting up of the two rotary sets is done in much the same way as in the single-phase rotary converter/d.c. locomotive. The two d.c. machines in parallel are supplied from the exciter driven by the Arno set. When the phase converter reaches synchronous speed it is connected to the main transformer through a reactor which limits the starting current surge and is then by-passed. Even distribution of the load between the six asynchronous motors is ensured, as far as possible, by limiting any differences in the wheel diameters (1100mm) to about 4mm or 5mm. The differences in the tractive effort developed by the six motors is thus kept to 10 per cent at half the maximum speed.

Regenerative braking is applied by reducing and then reversing the separate excitation of the d.c. generator by rotating the controller.

B_0-B_0 Locomotives

On the B_0-B_0 locomotives much of the mechanical equipment is common to both series. In general the mechanical design is based on that of the d.c. high-speed locomotives No. 9003 and 9004 which operate on the Paris-Lyons line. The bogies are similar, except that the underframe is of cast steel instead of being built up of welded steel plates as in the d.c. locomotives. The motors are suspended but because the maximum speed is limited to 75 m.p.h., the axleboxes are not rubber mounted.

One series of B_0-B_0 locomotives for the Valenciennes-Thionville line is driven, as already stated, by straight single-phase motors. On each of these locomotives the four eighteen-pole traction motors are connected in parallel and fed at variable voltage by a transformer. Because of the high secondary current (12,000A) in the transformer control is effected on the primary winding by a manually operated twenty notch voltage regulator which gives a ten to fifteen per cent change in tractive effort when passing from one notch to the next.

The traction motors have the following characteristics for continuous and one-hour ratings at half the maximum speed[1] :— Power, 680 h.p.; voltage, 250V ; current, 3000A ; power factor, 0·82 ; efficiency, 82 per cent ; torque, 5200ft-lb ; weight per foot-pound, 1·7 lb.

In the armature winding resistance connections are included between each coil and commutator segment, to improve commutation. They allow the flux and the power per pole to be increased. These resistance connections are made of cupro-nickel, insulated with glass silk, impregnated with silicon varnish. They are located on the armature spider below the laminated core where an effective ventilation path is provided for the cooling air.[2]

Compensating poles are dispensed with and a special system of shunting the interpoles is used. There are two shunt notches : one is for starting, in which the shunt circuit consists of resistance and capacitance in parallel ; the other is for use at higher speeds when the shunting is by resistance only. Accordingly, the transformation e.m.f. can be balanced at both high and low speeds.[1] To ensure optimum effect from this system the change-over from the *RC* to the *R* connection is effected automatically at a predetermined speed by a tachometric control device. Another factor in the limitation of the short circuit current is the use of brushes divided into three parts, each 10mm thick, and brush holders with insulated sides. The average wear on the brushes is stated[2] to be between 0·3mm and 0·4mm per 1000km, compared with the corresponding figures of 0·2mm to 0·3mm in the case of modern 1500V d.c. locomotives.

In the second series of B_0–B_0 locomotives the tractive effort is produced by four d.c. motors connected in parallel and supplied, at variable voltage, by eight ignitrons, through a transformer. Voltage control is achieved through a voltage regulator similar to that used on the locomotives equipped with straight single-phase commutator motors. However, because the ignitron locomotive has a steeper tractive effort/speed characteristic it was found necessary to insert between each of the twenty notches of the voltage regulator an intermediate notch on which the traction circuits are fed through a resistor.

The motors are series-wound, non-compensated, six-pole machines of normal d.c. construction, the ripple from the rectifier being reduced by a choke. The main poles can be shunted by resistive and inductive shunts, to allow four weak-field notches.

Silicon insulation is used and the motors have the following main characteristics :— Weight, 3030kg ; one-hour rating, 900 h.p. at 675V. The locomotives have a continuous rating tractive effort of 16 tons.

Each of the eight ignitrons is a single-anode water-cooled tube of 8in diameter, with a guaranteed continuous rating of 475A at 750V. The guaranteed overloads are 150 per cent of the rated load for two hours and 300 per cent for one minute, but it is believed[1] that the guaranteed figures can be surpassed in service.

Water cooling of the ignitrons is effected by arranging the coolers laterally in the superstructure. The transformer oil cooler is integral with the transformer, which is installed under the cab. There are only two motor-driven blowers for each machine, the oil coolers and water coolers being ventilated by the same fans that cool the traction motors. The electrical layout resembles that of the Pennsylvania locomotives.

The B_0–B_0 locomotives for this electrification are being supplied to the S.N.C.F. by the group known as M.T.E. (La Société "Le Material de Traction Electriques "), which consists of the following three companies :— Société de Forges et Ateliers du Creusot (Usines Schneider) ; Forges et Ateliers de Constructions Electriques de Jeumont; and Le Matériel Electriques S.W. (Schneider-Westinghouse).

The capabilities of some of the foregoing locomotives when hauling freight trains were well demonstrated during the recent S.N.C.F. convention at Lille on single-phase electric traction at industrial frequency. The demonstrations were carried out during heavy rainfall on May 13th at Querenaing halt, near Valenciennes, where goods trains were started on a 1 in 100 gradient. In the first test a goods train of 1855 metric tons was started by an Alsthom locomotive, No. CC14110, equipped with synchronous rotary converter/d.c. drive. In the next test a goods train of 1405 metric tons was started by an M.T.E.-S.W. locomotive, No. BB12006, equipped with ignitrons.

These demonstrations do not represent optimum performances. We learn, for instance, that during tests on May 5th last, a locomotive, BB12006, with ignitrons, hauled a train of 1710 metric tons from Lumes to Valenciennes and back on the line between Valenciennes and Charleville. Twice during these runs it was successful in starting and hauling this load on a rising gradient of 1 in 100. During these tests the maximum effort at the drawbar reached 39 tons, with a sustained effort of 35 tons for twenty-one seconds. The corresponding adhesive factors may be fixed at between 41 and 48 per cent, which, for simple adhesion locomotives, exceeds the best results known hitherto. It is also stated that locomotives of the CC14100 class have succeeded in starting and hauling trains of well over 2000 tons, also on a rising gradient of 1 in 100.

(To be continued)

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Gas Grid Projects

With the recent completion of a large new project, the grid system of the North Thames Area Gas Board extends to all parts of the area served by the Board. In another large project which is in hand by the North Wales Area Gas Board American pipeline laying methods are being used. In the article below we give notes on these two projects and points of interest in their layout and construction.

SOME very large projects are being carried out in this country by the various area gas boards to provide adequate supplies of gas to new industrial areas and improve the supplies to existing industrial and residential districts. An important part of this work is the construction of gas grids and for this work full use is being made of the latest equipment and methods to speed construction and promote economies.

A large pipeline scheme recently completed was the laying of a main over 25 miles long between the Fulham gasworks and Slough, at a cost of £1,160,000, by the North Thames Gas Board. With the completion of this line the board's grid system now extends to all parts of its area from Southend in the east to High Wycombe in the west. When the route of the new pipeline was being planned it was decided not to install a main directly between Fulham and Slough but to take advantage of the scheme to provide extra supplies of gas to Richmond, Twickenham, Feltham, Ashford and Staines. For this reason the line is much longer than it would otherwise have been and its construction involved a number of engineering problems. It was calculated that, allowing for future development, the quantity of gas delivered at Slough should be 20,000,000 cubic feet daily, while other amounts should be taken off at towns along the route. For this supply the most economical combination of pipe was found to be 36in diameter from Fulham to Shortwood Common, Staines and from there to Slough, 30in diameter. An initial pressure of 5 lb to 6 lb per square inch was decided upon. To cope with any extra demand in the future calling for higher pressures additional pumps have been provided at Richmond, and the line itself has been tested to 20 lb per square inch.

Most of the new gas line is built of cast iron pipes, whilst at special crossings of rivers and railway lines steel pipes are used. The work called for no less than 18,000 tons of iron and 500 tons of steel pipes.

The biggest obstacle encountered in the project was the crossing of the Thames and eventually, with the permission of the British Transport Commission, a new cantilever support structure was built on the west side of Putney railway bridge to carry the pipeline. The line over the bridge is of welded steel construction and incorporates very large corrugated expansion joints. Motorised valves are fitted in the line at each end of the bridge to enable the gas supplies to be cut off immediately in the event of an accident to the bridge. This part of the line is electrically insulated from the bridge structure and the earth at each end. The pipe is supported on the bridge structure by carriages providing means of movement for thermal expansion and level adjustment, and one of

One of the supporting carriages for the pipeline over the River Thames

these carriages can be seen in the illustration above. Brackets depending from the pipe cradle are supported through a cross shaft on profiled rollers. These rollers move on a heavy bed-plate supported on the deck through insulated jacking legs by which level adjustments can be made.

A further difficulty was encountered where the line again crossed the Thames at Twickenham Bridge. Here there was not enough height for the 36in pipe to be accommodated under the footpath and to overcome this problem oval steel pipes, 30in high by 44in wide, were used. Further on the pipeline had to cross the River Colne at Stanwell Upper Mill and in order to preserve the appearance of the bridge it was necessary to lay the pipe out of sight. The bridge itself is only 2ft deep and as the pipe here is 30in diameter special measures had to be adopted. For this reason the special pipe section shown in the illustration on page 784 was developed. This section of pipe forms an integral part of the bridge structure and replaces an existing section. The bridge is made of steel troughing and the pipe of steel plates and sections fabricated in the form of a rectangular box welded on to the main structure is an integral load bearing member.

In other sections the work involved extensive pumping to keep the trenches clear of water in flat, waterlogged ground, and the crossing of railway lines with a minimum dislocation of traffic.

North Wales Gas Grid

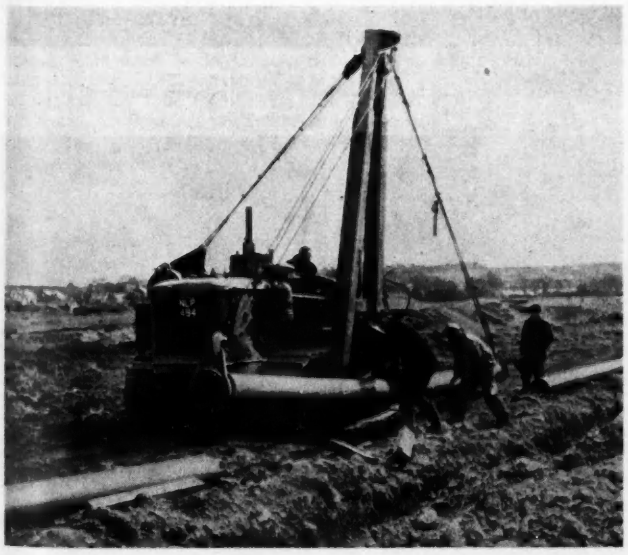
Another large gas grid project being carried out is that of the North Wales Area Gas Board in which another stage will be reached this year with the completion of the gas grid from Connah's Quay to Caernarvon. Part of the principal section of this grid has already been laid between Llangollen and Connah's Quay, and centres on the recently completed Maelor gasworks. In addition to coal gas from those works, the system will obtain coke oven gas from the plant of John Summers and Sons, Ltd., at Shotton, and methane from the National Coal Board's colliery at Point of Ayr. The methane obtained from the coal seams will be reformed so as to be interchangeable with coal gas.

When all the projected extensions are completed, the North Wales grid will supply twenty-five undertakings with, at present, some 70,000 consumers. The total of high pressure mains will amount to approximately 130 miles, and a saving of 76,000 tons of coal will be made annually.

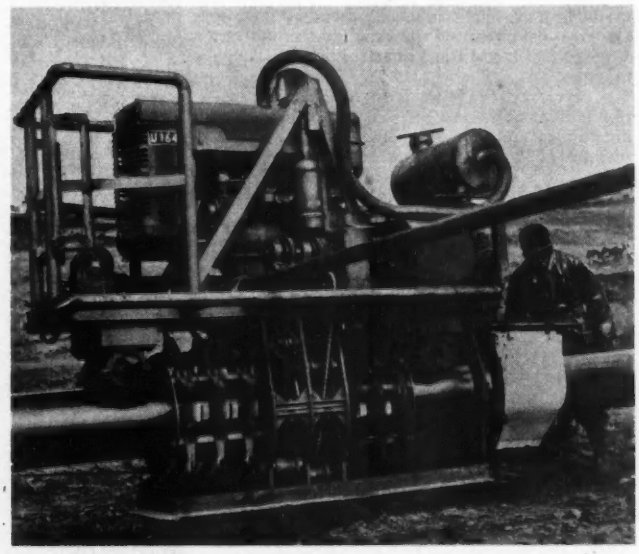
In order to achieve the maximum speed of construction for the least cost (and inconvenience to the public), the pipe is being laid not in the roads but by cross-country routes. The methods used are those developed for oil pipelines in the United States during the past twenty years, and used here (and at a similar scheme in South Wales) for the first time in Great Britain. While oil pipes in America are being laid at rates of 1–2 miles per day, the daily average in the present operation is about ½ mile, although ¾ mile per day has been frequently exceeded.

The principle of the American method consists in subdividing the work of a "spread" among a number of teams which follow one another at the site with the least possible interruption. It is the task of each team to try to catch up with the team in front and to keep ahead of the team behind it.

In advance of the main operations, a right-of-way crew clears a strip 40ft wide of all obstruc-



Bending machine equipped with side boom and spreading shoe, bending a length of 12in diameter pipe



Self-propelled cleaning and priming machine. Encircling the pipe are the rotary scrapers and brushes

tions, such as hedges, walls and fences. If necessary the strip is cross-graded to provide a site which is laid in a direction at right angles to the pipe. Ditches are bridged and temporary wire fences are erected to keep cattle from straying.

A 4ft trench is then dug in two stages, using a "Cleveland 110" and a "Cleveland 240" rotary bucket excavator, respectively. These machines discharge on alternate sides of the trench, and in this manner topsoil and subsoil are kept separate. The total depth of 4ft means that the pipe when laid is under 2ft 6in of earth cover and thus out of reach of farming operations and undisturbed by changes in temperature.

The stringing crew then transports the 40ft long pipes to the site, using tractor-drawn pole wagons. The pipes are laid out along the trench

Special rectangular pipe which also forms part of the bridge structure over the River Colne

ready for line-up and welding. The pipe edges are previously prepared for welding in the factory where the pipes are also given an internal coat of red oxide paint. Where required bending (to a minimum radius of 30 diameters) is done on site, using a side-boom tractor equipped with bending shoe, as shown on page 783.

Each pipe section is then lined up with the line by means of an internal expanding mandrel, and tacked on by electric arc welding. The two welders concerned then move to the next section to be tacked, and are followed by another two who apply the first complete welding run, after which two more welders apply the second and the final run. Welding is done by the overhand method, and the procedure just described is stated to have reduced the time for one joint of 12in pipe from one and a quarter hours to sixteen minutes.

A percentage of the welds are tested by gamma-ray radiography, and sections of 1000ft-4000ft are capped and tested for leaks by applying air pressure at 100 lb per square inch.

Coating is next applied in two stages. First a motorised rotary brush, shown on page 783, travels along the pipe and, after cleaning the pipe, applies the primer. When this has dried, a second machine applies a coating of hot coal tar about $^{3}/_{32}$in thick, and immediately afterwards wraps the pipe with fibreglass tape. When required, a second layer of impregnated glass fibre tape is applied on top of the first. The coating is tested for imperfections such as pin-holes with a spark detector. After any faults have been made good the pipes are lowered into the trench by two side-boom tractors. Back-filling and reinstatement of the right-of-way complete the operation. It is intended to protect the pipe further by making it the cathode in an "improved current" circuit, and tests are being conducted on which the scheme will be based.

LAUNCH OF COASTAL MINESWEEPER.—The coastal minesweeper H.M.S. "Hildarton" was launched on May 23rd at the Belfast yard of Harland and Wolff, Ltd. The ship has a length of 152ft by 28ft 9in beam.

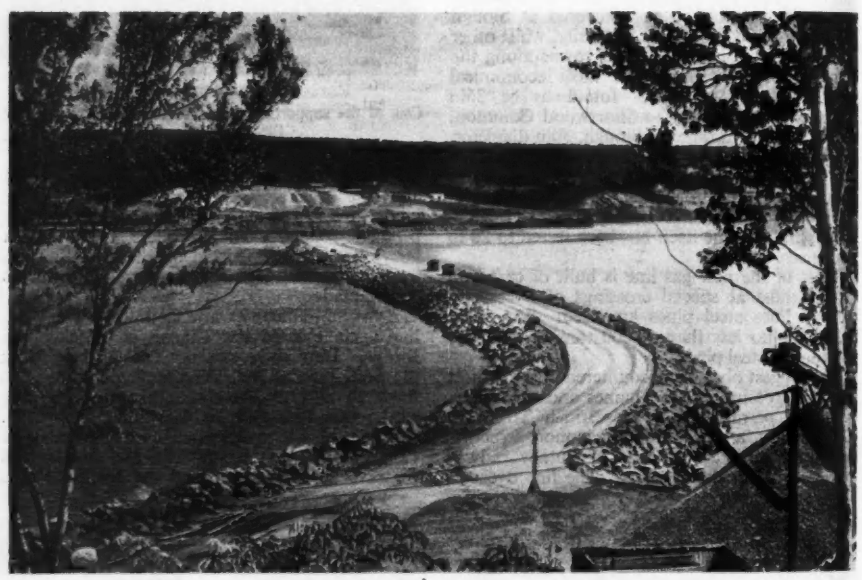
Strait of Canso Causeway

BY OUR CANADIAN CORRESPONDENT

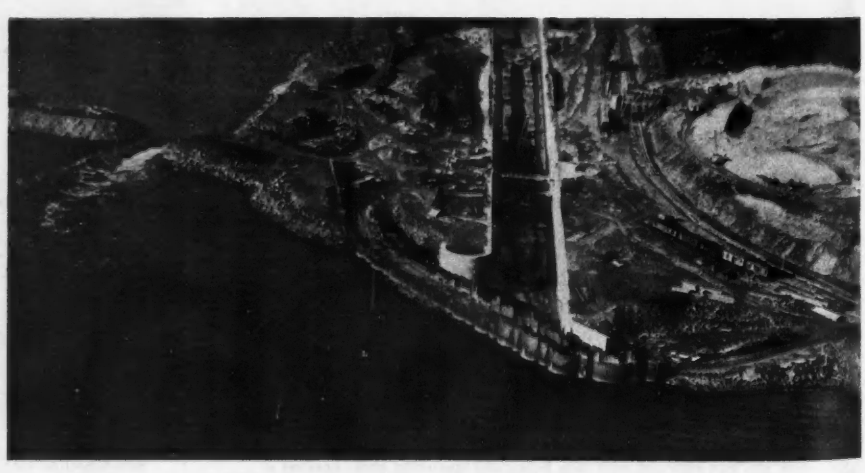
CAPE BRETON ISLAND, the large island forming the northern part of the Province of Nova Scotia, is divided from the mainland by a body of water forming a narrow strait between the Gulf of St. Lawrence and the Atlantic, which is subject to severe storm, ice and tidal conditions. For years this 3600ft wide gap, the Strait of Canso, has been an obstacle to the economic progress of the northern section of the Province, and it is only the recent completion of a rock and earthfill causeway that will open a rail and motor vehicle route to Cape Breton's steel, coal and wood product industries. The first rail connection, dating back to 1891, was a tug and barge arrangement, later giving place to two ferries, which, nevertheless, involved over an hour in the handling of passenger trains across the strait, and in the case of motor vehicles the delay was often longer.

The effect of such traffic delay had marked reaction upon the business of the Province, where Cape Breton's coal industry employs 9000 of the provincial population of 157,000 inhabitants, and produces 38 per cent of the nation's total coal production. Likewise, over £17,500,000 of steel is produced per year in Cape Breton, which has a land area of but 3970 square miles. Besides this industrial progress, the island has a very active tourist business, and the inadequacy of the existing ferry service had adverse effects on the economy of the Province as a whole, and Cape Breton Island in particular. Although for fifty years it has been indicated that the Strait of Canso would need a more serviceable crossing than the existing ferry system, it was not until the Federal Government agreed to participate in the undertaking that an independent Strait of Canso Board of Engineers was set up in 1948. The final result of the investigations of four alternative crossings—causeway, bridge, tunnel or improved ferry service—indicated that the causeway crossing would be the most advantageous. A bridge crossing was rejected after initial plans had already been made, because of the drift ice and tide flow (1,250,000 cubic feet per second) through the gap to which the piers would be subjected.

The project was designed by O. J. McCulloch and Co., of Montreal, and entails three separate work projects. The first, completed last year, is the rockfill causeway itself. The second, now in its final stages, is the rail and road approaches on both sides of the strait, and the third, which is under construction, is an 850ft navigation lock on the Cape Breton end of the causeway. A start was made on the project in May, 1952, the general contractor being the firm of Northern Construction Company and J. W. Stewart, Ltd.,



Construction of the causeway is here seen in progress from the Nova Scotia mainland



The navigation lock of the project on the Cape Breton Island, with closure of the causeway almost completed

but it was not until September of that year that quarrying and dumping got under way.

The causeway, which is 4300ft long, extends from Balache Point, on Cape Breton Island, to a point near to Cape Porcupine on the mainland. It is slightly "S"-shaped and curves diagonally from south-west to north-east, and is 80ft wide at the crest, with an extreme width at the base of about 800ft, where the maximum depth of 180ft is reached. When the whole project is completed the causeway will carry a two-lane 24ft highway, a single-track rail line, and a foot pavement. The crest will be 14ft above high water and 20ft above the low water mark. Its wide base of 800ft gives the sides a designed slope of 1½ to 1 to 1½ to 1. The faces of these slopes were covered with rocks of a minimum weight of 8000 lb each as a defence against erosive weather conditions. Approximately 160,000 cubic yards of riprap rock material was used, with a total of over 9,000,000 tons of fill in the causeway construction. The construction of the causeway was accomplished in about twenty-eight months of work, with a force of 170 men. The rock was obtained from the adjacent Porcupine Hill, being loaded in Euclid trucks, to be dumped into the strait from the progressively lengthening causeway. Because of the heavy strain of floating ice during the winter season the riprap was carried to 5ft below low water on the south side of the causeway and to 10ft on the north side.

The advantageous location of the 600ft high Porcupine Hill, within 1600ft of the end of the causeway, on the mainland shore, provided an abundant supply of granite, the area of quarrying having a 1600ft frontage, with a depth of over 500ft. This hill provided an opportunity for the utilisation of the "coyote tunnel" method of quarrying, which system also had the added advantage of providing mixed material for fill and large riprap rocks. To enable the trucks to reach the three quarry levels, which were at elevations of 20ft, 125ft and 250ft, two access roads were constructed. In the system of "coyote tunnel" quarrying a tunnel of "T" shape is driven, the cross of the letter representing the quarry face and the stem the access tunnel. Two cross cuts are made when the stem is of considerable length. In Porcupine Hill the general practice was for the addition of another cross cut at around a 45ft to 50ft distance from portal, if the stem length was 100ft, and the working face was longer than 100ft. Otherwise, where the face was under 100ft the access tunnel would be about 50ft long. The entries, approximately 3½ft by 5½ft, were arranged in groups of two or more, and in order to leave a distance of 25ft of rock between the extremities of the cross cuts the tunnel portals were spaced at a distance of 125ft apart.

Blasted rock in the tunnels was brought out by 30in drag scrapers, pulled by double-drum air hoists. Upon reaching the portal the rock was moved by electric shovels of 6 cubic yard capacity, loading the material into the 34-ton Euclids. An average of 50,000 tons per month greater than the 350,000 tons specified in the contract was placed. The Euclids ran twenty-four hours a day, six days per week, with one day a week for complete servicing. In this way they maintained 144 hours of duty per week for 2½ years, with three shifts of drivers, each twenty-four-hour period. Service breakdowns were almost totally avoided.

The final closing of the gap between the two shores was made on December 10, 1954. The lift bridge, recently completed, over the lock and canal, was built by the Gorman Construction Company. This work, on the Cape Breton side, involves the most detailed part of the project, where, besides the lock, canal and bridge, sea walls, anchoring basins, and rail and road approaches are being constructed. The channel will be 1950ft in length by 80ft wide and there will be 32ft of water over the sills of the lock at the lower level. This stage will have gravity walls of about 47ft in height. The sliding gates are situated 820ft apart and are called upon to resist pressures from both sides of the gates, not only of tide but of drift ice, and high wind. The bridge over which all traffic will pass is a 300ft lift span on the south-east end of the canal.

Work is still in progress on the canal, where a 900ft steel-sheet-piled cofferdam has been built. Besides the navigation canal and lock, extensive breakwater and dock installations are being constructed at both ends of the cut, where mooring basins and docks will serve vessels awaiting passage through the canal. By the time the channel is completed it is estimated that 400,000 cubic yards of material will have been dredged from the entrance, which will then allow the passage of vessels from the Atlantic to the Gulf of St. Lawrence. The causeway will provide a check for ice flow in wintertime and the south side of the barrier should provide a deep sea harbour open the year round, safe from ice drift and other natural hazards. The construction of the causeway and lock necessitated the relocation of the railway, the old route lying too close to the proposed area of excavation for the canal. The present route is approximately 125ft inland from the lock side, at about elevation 20, from which a spur line will be taken when the rail is run across the causeway. The railroad approach work was carried out by the Wasson Construction Company.

The official opening of the entire project is due to take place in the latter half of this year, even though the two shores are now joined and the vertical lifting span over the canal is now complete. In constructing the causeway, besides the 9,000,000 tons of rockfill and 160,000 cubic yards of riprap quarried, approximately 100 coyote tunnels have been blasted and 17,000ft of adit and cross-tie tunnels had been driven.

Bar Heat-Treatment Plant

THE heat-treatment shop for alloy steel bars at the works of Sanderson Brothers and Newbould, Ltd., Newhall Road, Sheffield, has been modernised and re-equipped to facilitate the production of the bars the firm supplies in the heat-treated condition. The new plant can be seen in the illustration below and it comprises two hardening furnaces, a tempering furnace, an oil and a water quenching unit, and a revolving floor charging machine. The furnaces were designed and built and the equipment installed by Fuel Furnaces, Ltd., of Birmingham.

The two gas-fired hardening furnaces each have a working chamber 16ft 6in long, 5ft wide and 1ft 9in high, and they are designed to take a maximum charge of 3 tons. They are under-fired and in them the products of combustion are induced downwards through the load to give even, balanced heating. Temperature control is in two zones, and the proportional gas-air system is employed, each furnace being equipped with thirty burners having measuring jets for both gas and air. The waste heat is used to preheat the air for combustion in a recuperator in the arch and side walls of each furnace. Three slots in the hearth accommodate the arms of the charging machine during the loading and unloading operations.

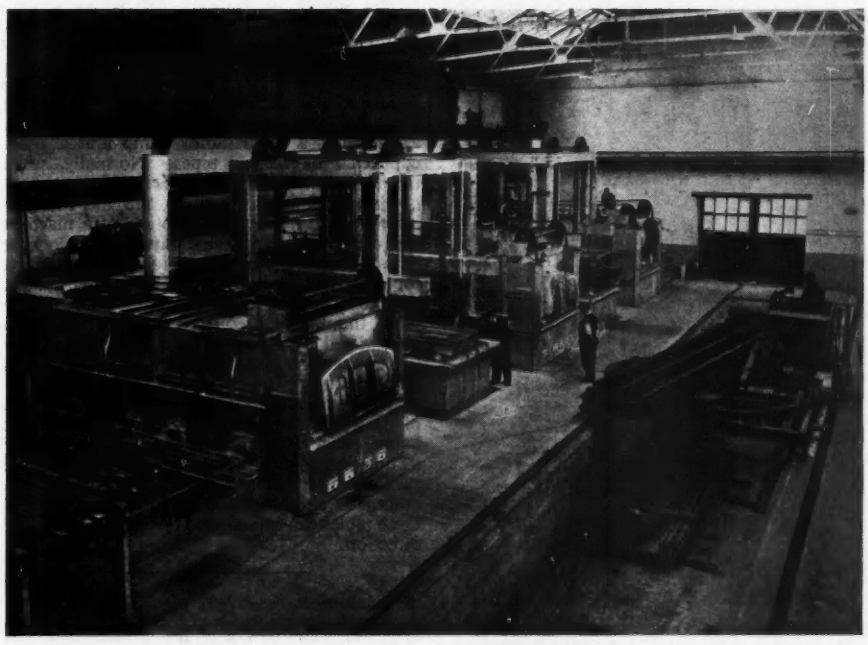
The tempering furnace has a working chamber of similar size to that of the hardening furnaces and operates on the over-fired principle. It is designed for high-velocity circulation of furnace gases up to 700 deg. Cent. When working above this temperature up to the maximum of 850 deg. Cent., circulation is induced as in the high-temperature furnace. If desired, the recirculating fans can be arranged to cut out automatically on the temperature reaching 700 deg. Cent., and to restart when the temperature falls below 700 deg. Cent.

For normal tempering operations which are, of course, done below 700 deg. Cent. the gases of combustion recirculate through the load and hearth at high velocity, passing through ports situated between the burner ports. Eight horizontal nickel chrome centrifugal fans, operating in cast iron collecting chambers below the hearth, draw the furnace gases through the load and re-inject them into the chamber. This recirculation of gases not only imparts a more even temperature—it also enables the excess waste gases to be used for a frontal curtain to prevent ingress of air through the door, thereby reducing oxidisation. The thirty burners, with identical jets for gas and air, are divided into two zones for temperature control purposes and an air recuperator is fitted.

For proportional gas-air temperature control purposes each furnace is divided into two zones—rear and front—with a pyrometer to record the temperature in each zone. The six Kent "Multilec" temperature recorder controllers and ancillary equipment for temperature control purposes are mounted on a panel adjoining the furnaces.

The quenching tanks are set in line and between the furnaces. That used for oil quenching has a capacity of about 4300 gallons and is fitted with a reciprocating table for the bars. This table is suspended from chains coupled at the other end to pneumatic cylinders. On bars being placed on the table it sinks into the tank and a cover is automatically lowered into position. The table is then moved up and down in the tank by the pneumatic cylinders until the quenching operation is completed. During the quenching period the oil is continuously circulated and pumped through a cooler to prevent overheating of the bath.

The water quenching unit is generally similar in construction to the oil quenching unit, but is



Heat-treatment shop for alloy steel bars

not provided with a cover or circulating equipment. A supply of cold water is pumped through this tank during quenching, river water being used generally, although a supply of town's water is available for use in emergency.

A loading table of prefabricated steel on which the charges of bars are built up adjoins the hardening furnaces, and a second table is set near the tempering furnace. Bars are loaded on to these tables by an overhead crane and they are slotted to admit the arms of the charging machine.

The charging machine traverses along rails in front of the furnaces and it is fitted with a rotating arm assembly, as shown in our illustration. Its three loading arms have a movement of 18ft along their support carriage. The three movements of lifting, charging and traversing are each driven by a separate motor controlled from the operator's cab and interlocked so that the carriage cannot be rotated until the arms are fully withdrawn from the furnaces.

Hydraulically Operated Indexing Table

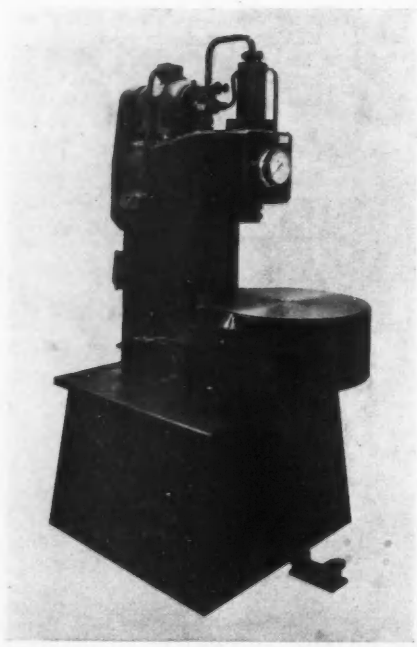
A HYDRAULICALLY operated indexing table has been developed by John Mills and Co. (Llanidloes), Ltd., Llanidloes, for use on presses of up to 45 tons, or other machines. In the accompanying illustration the table is shown fitted on one of the firm's standard "Oilaulic" 6-ton bench presses, from which it derives its hydraulic power.

The table is a solid disc 2¾in thick with an integral central stem working in ample bearings in the cast iron housing. A gear ring shrunk on the underside of the table is driven by a hydraulic motor through a pinion carried in ball and roller bearings. To ensure easy rotation of the table the contact surfaces are separated by a spring-loaded ball which, except when working loads are applied, acts as a thrust bearing to take the weight of the table and tooling. When the table is under load the spring yields to allow it to rest firmly on the cast iron bed of the housing.

Taper ground sockets for the index plunger are sunk in accurately spaced recesses in the underside of the table. This index plunger moves in a steel sleeve in the housing and it is engaged by a spring and withdrawn by a hydraulic ram. This ram also acts as a piston valve through which oil is only admitted to the motor when the indexing plunger is fully withdrawn.

When the table is in the standing or locked position, the oil supply is by-passed via the main piston valve, which is held down against spring load by a catch, and a by-pass valve which is held up by a spring. When the catch on the main valve is tripped the spring lifts the valve, admitting oil to withdraw the index plunger and then to drive the motor, and to depress the by-pass valve.

Corresponding to each station on the table there is a cam so placed on the periphery that as the index point is approached the cam acts on a roller on the main valve, depressing it so that the catch engages. In this position oil is released from the index withdraw ram allowing the plunger to bear on the underside of the table.



24in diameter hydraulically operated indexing table with twelve stations, fitted to a 6-ton press

At the same time the motor exhaust passes through an adjustable orifice, checking the speed of the table, so that when the index point is reached, engagement takes place without shock. As the plunger engages, its withdraw ram valve releases pressure from the by-pass valve mentioned above to exhaust the whole circuit. Until then pressure has been maintained on the motor through the by-pass valve, thus ensuring positive action in spite of the retardation.

When fitted on a hydraulic press the pressure supply to operate the table can usually be taken from the pump powering the press. On other applications a small motor pump unit is used, connected by flexible pipes. Normally, when the table is fitted on a press the return movement of the press ram is used to trip the catch to initiate indexing, but any motion of a machine tool can be used in the same way, and interlocking is provided to prevent operation of the machine tool except when the index plunger is engaged. To allow time for loading or re-assembly on the table, the machine sequence can be arranged to be initiated by indexing, followed automatically by the machine cycle, during which loading can be carried on.

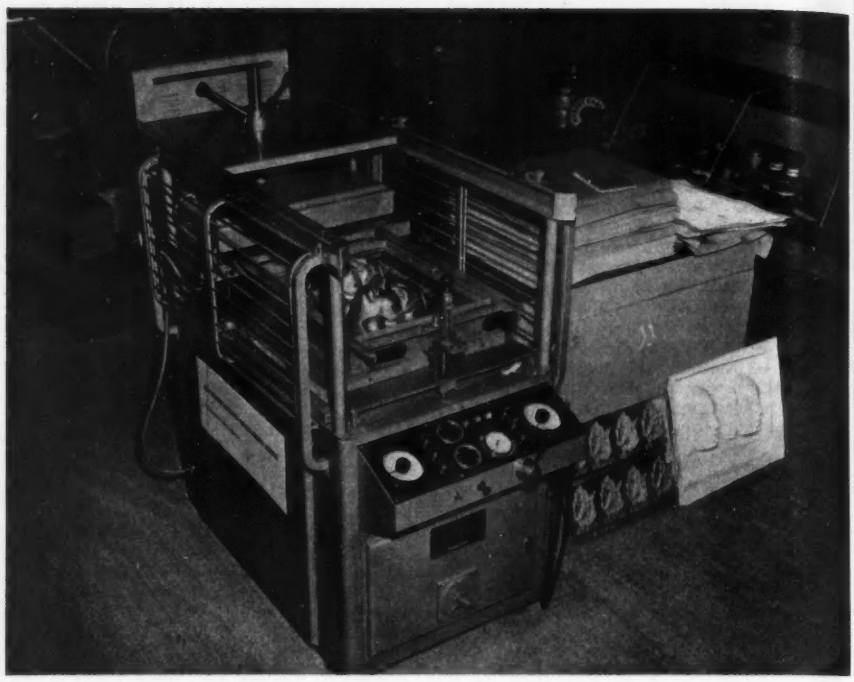
In the standard equipment the working surface of the table is 24in diameter, the station centres being on a 16in diameter. Any number of stations up to twelve can be provided, and the stations can be selected by setting the cams. An automatic ejector can be fitted if required, and these tables can be supplied for rotation in either direction.

STEEL PRICE CHANGE.—The Iron and Steel Board has announced some changes, both upward and downward, in the maximum prices of certain non-alloy steel wire rods, according to area of delivery, quality and size. The revised prices came into effect on May 30th.

Automatic Vacuum Forming Machine

A VACUUM forming machine for thermoplastic sheet, which works on an automatic cycle is now being made by the Latymer Engineering Company, Ltd., 27a, Charles Street, London, S.W.13.

The machine has a rigid cabinet base, on the table of which is mounted a mould box fitted with toggle operated clamping strips round its sides for locking the plastic sheet to be formed. Supported on a roller carriage running on a pair of longitudinal slides above the table of the machine is a 25in by 27in infra-red blanket heater with a 3½kW loading. This heater is adjustable for height in respect to the mould box, and it is moved backwards and forwards between the mould box and its rest station at the end of the machine, as shown in the accompanying illustration. The mould box itself is connected to a vacuum cylinder in the base of the machine, and this cylinder is exhausted by an integral motor-driven pump whilst the machine is in operation.



Automatic cycle vacuum forming machine with heater retracted and mould box ready for attachment of plastic sheet

The working cycle of the machine is controlled by two process timers, one of which controls the movement of the heater and the other the time which the vacuum is applied to the mould box. When a plastic sheet has been clamped on the box frame and the height of the heater adjusted in accordance with the thickness and material of the sheet, the automatic cycle is started. The heater traverses along to register over the box and at the conclusion of the preset heating period returns to its rest position. The valve to the vacuum cylinder is then automatically opened and on the air exhausting from the box the softened sheet is pressed firmly into contact with the mould by atmospheric pressure.

A blast of air directed on the sheet speeds the cooling before the formed article is removed. Evacuation of the mould is effected through either of two valves, one of which is used when forming thin sheet material and the other, which is slower in action, when forming thicker material or when drawing with deep patterns. It will be appreciated that once the cycle timing has been determined all that is necessary is the loading of the plastic sheets and removal of the mouldings.

The new automatic machine is a development of a hand-operated design demonstrated at the last British Industries Fair on the stand of Bakelite, Ltd., where it was shown working with rigid and flexible "Vybak" p.v.c. sheet.

Haweswater Aqueduct

By A. ATKINSON, M.I.C.E.*

The second stage of the Haweswater water supply scheme, involving an aqueduct from Garnett Bridge to Haweswater, is now almost complete. The scheme is one of the largest civil engineering projects carried out in this country in the post-war years. The account given below is abstracted from a paper entitled "Manchester Waterworks—1945–55," presented at the Institution of Water Engineers' summer meeting on May 18th.

At the present time, Manchester is supplied with water from three separate sources—Longdendale, Thirlmere and Haweswater—as shown in the accompanying map. Powers were obtained in 1919 for the Haweswater supply, which is to be developed by instalments. The scheme as authorised will yield 72 m.g.d. for town supply and 9 m.g.d. for compensation water. The gathering grounds have an area of approximately 24,000 acres, and the whole area has been acquired by the Corporation. The long-period average annual rainfall varies from 102in in the south-west of the area to 59in in the north-east.

The first instalment of the scheme comprised : the Haweswater dam (by which the level of the original lake was raised 95ft) and various ancillary works. The reservoir created by the dam has a T.W.L. of 790ft A.O.D. and a capacity of 18,662 million gallons ; the first 9 miles of aqueduct between the Haweswater reservoir and Garnett Bridge, Longsleddale, near Kendal (*A* to *B* on the map), and a 2¼-mile, 30in, steel pipeline (the Sprint siphon) forming a connecting link from the Garnett Bridge micro-strainers into the Thirlmere aqueduct, at the Mint siphon north well (*B* to *C* on the map). These works were brought into use on October 2, 1941, and enabled 13 m.g.d. to be sent from Haweswater to Manchester via the Thirlmere aqueduct.

The second instalment consists of the main aqueduct and the first line of pipes between Garnett Bridge and the No. 1 Audenshaw reservoir, Manchester (*BDE* on the map). In August, 1939, the waterworks committee had decided to proceed with the construction of these works, but the outbreak of war made it imperative to postpone the project. The construction of the second instalment began on April 1, 1948.

Early in 1948, upon the author's recommendation, the Corporation decided to increase the size of the tunnels from 7ft 7in to 8ft 6in internal diameter, and to increase proportionately the sizes of the other "full capacity works." The maximum capacity of the aqueduct was increased from 81 m.g.d. to 105 m.g.d., which will provide for enlargement of the Haweswater scheme to meet reasonable foreseeable increased future demand. There are ample water supply sources adjacent to Haweswater which can conveniently be added to the 1919 scheme. Provision has been made in the design of the aqueduct for the filtration and treatment in the future of the whole augmented Haweswater supply.

The aqueduct is 82 miles in length (73 miles in the second instalment works), and is the principal civil engineering work of the Haweswater scheme. It consists of 30·85 miles of concrete-lined tunnels of 8ft 6in diameter ; 7·96 miles of covered concrete channels ("cut-and-cover") of 8ft 6in diameter ; 3·84 miles of steel-cored concrete, single-pipe siphons of 8ft and 7ft 3in diameter ; 30·34 miles of steel multi-pipe siphons (normally four lines) ; 9·20 miles of steel pipe siphon—Heaton Park to Audenshaw reservoirs.

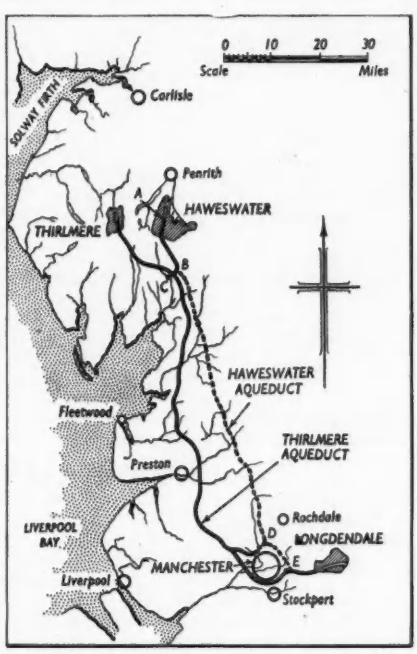
There are four long and four short tunnels, having an aggregate length of 26·31 miles. All tunnels have an internal diameter of 8ft 6in, a gradient of 1 : 3000, and are lined with concrete having a nominal thickness of 14in, 16in and 18in, according to ground conditions.

Bowland Forest Tunnel

This 10¼-mile tunnel, which connects the Lunesdale and Hodder steel pipe siphons, occurs about midway along the aqueduct and is located in a very sparsely populated moorland area difficult of access. The central length is very deep, and as it was impossible to avoid the 4-mile drive between the Hindburn and Croasdale shafts, construction was begun about eighteen months in advance of the other aqueduct works. The contract was placed in December, 1947, and site work began on April 1, 1948. There are three permanent shafts—Hindburn, Croasdale and Ellerbeck, respectively 45ft, 265ft and 90ft in depth.

The tunnel was driven to a "horseshoe" profile (11ft by 11ft). For a distance of 9000ft at the southern end it passes through limestone, the remainder of the 10-mile length being in conglomerates, gritstones and shales. Whilst numerous faults were met, ground conditions in general were only specially difficult in two or three sections. Conditions, however, varied considerably to the extent that in one favourable stretch the contractors drove a record length (334ft) from a single face in one week. Except for short lengths where the roof was supported by the Beijl system (4ft to 6ft long anchor bolts carrying roof support plates), the necessary temporary support was given by 5in by 4in steel colliery arches, normally at 4ft centres, with ⅜in steel corrugated "bank bars" or polings. The total weight of steel used was 7532 tons, and 83 per cent of the tunnel length needed temporary support.

All steel was subsequently incorporated in the concrete lining. In certain sections where there was soft and difficult ground, poling or similar methods were necessary ; but in some of these cases the author considers that the use of precast reinforced concrete segments and a shield would have provided a better solution of the support problem.



Sources of supply and aqueducts to Manchester

In soft shale or mudstone which deteriorated rapidly on exposure to air and water, and occasionally in other circumstances, it was essential to build side walls of concrete between the steel arches, up to about axis level, to give additional side support and to prevent movement and distortion.

Drilling was done by compressed air, using the conventional percussion drifters mounted on a heavy drill carriage, the 1¼in drill steels having detachable bits, which were sharpened by a hot miller.

Spoil was cleared after firing by Eimco 21 loaders filling 40 cubic feet capacity "U" cars on 2ft gauge rail track, with a "California" switch kept as near to the face as possible.

Electric locomotives were used for haulage at the face, with diesel locomotives for the supplementary work. Ventilation was effected by blowers through 22in diameter ducting.

A large volume of water was tapped, especially in the sections having considerable rock cover. The biggest inflow was in the drive south from Hindburn, when a maximum of 96,000 gallons per hour was encountered.

Concrete Lining.—Lining was deferred until the whole of the driving had been completed and the concrete sub-floor laid, the sole exception being the short length between Well Beck and Mill Beck, which was lined immediately after driving, owing to bad ground conditions, which had produced distortion and movement of the steel arches. Suitable sandstone was available near the Croasdale shaft and a quarry was opened out to provide both coarse aggregates and sand. The 18ft diameter Croasdale shaft was stripped of its gear, and bins were inserted for the storage of aggregate, sand and cement, which were batched and mixed at the bottom of the shaft. The concrete from the tilting drum mixer was discharged into 2-cubic-yard remixer transit cars of the non-tilting type with drum end discharge. The fifteen cars were made up into five trains each of three cars. The complete cylindrical concrete lining was placed in one operation, and concreting was carried out continuously except for the week-end break.

Placing was effected by a "Pressweld" pneumatic placer in conjunction with a specially designed 200ft long steel shutter. The shutter design enables a 20ft section to be struck at the rear end and, without interruption of the concreting, to be moved through the shutter by means of a wheel-mounted box-girder transporter with an overhanging boom, and re-erected in its new position at the leading end, the procedure being repeated as necessary, as the placing of the lining advanced. This equipment was efficient, and enabled 51,850ft of lining to be completed in sixty-eight weeks.

Extensive grouting was carried out to fill all cavities between the concrete and the rock, to make good at construction joints, and to seal off inflows of water. The total cement injected was 22,400 tons, equivalent to 8·3 cwt per linear foot of tunnel. The contract was carried out on the normal basis and the work extended over seven years. The final cost is expected to be approximately £3,600,000.

The Rossendale Tunnels

The lengths of the Haslingden and the Walmersley tunnels are approximately 5·32 and 6·02 miles, respectively. They extend from Huncoat, near Accrington, at the north end, to Gypsy Brook, Bury, at the south end, and are connected together at Townsendfold, Rawtenstall, by a 501ft length of "cut-and-cover" constructed within a steel sheet piled trench, which crosses the River Irwell about 12ft below its bed. Construction occupied five-and-a-half years.

In November, 1946, agreement was reached for the purchase of the necessary pillar of coal in the Upper Mountain and Lower Mountain Mines, to support a length of 1500 yards of the Haslingden tunnel, subject to agreement on the spacing of the necessary access roads through the pillar to avoid severance.

Driving.—The tunnels were driven to a "horseshoe" section, normally 11ft by 11ft, entirely through the grits and shales of the coal measures ; except that near the River Irwell there is a 500 yard length through glacial drift of boulder clay and sand. The three shafts at Rising Bridge, Brynbella, and Shuttleworth were, respectively, 332ft, 134ft and 200ft deep to tunnel formation level, with drainage sumps sunk a further 30ft.

Considerable water (1·75 m.g.d.) was met in sinking the Rising Bridge shaft, which stopped progress. It was necessary to line a 40ft depth with cast iron segments, and to follow up by very heavy grouting which reduced the water to 100,000 gallons per day, and allowed sinking to proceed. Submersible pumps proved very satisfactory for dewatering the sumps.

Specially designed headgears were erected at each shaft, capable of winding and disposing of the spoil arising from continuous three-shift working, with the minimum labour cost.

Driving was carried out from the north and south portals and each way from the bottoms of the three shafts ; also from a portal at Townsendfold, 27ft below ground level, with access by a ramp excavated between steel sheet piling.

After extensive tests the best type of drilling equipment was found to consist of five drills mounted on air legs, with ⅞in hexagon drill-

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steel rods 6ft long having detachable tungsten-carbide cross-bits, at each face.

Ground support was given by 6in × 5in × 25 lb steel arch ribs, normally at 5ft centres with ¾in bank bars. It was impossible to maintain adequate supplies of arches during the steel famine of 1951 and 1952, and large quantities of scrap rails were bought and bent into arches, either on the site or by outside sub-contractors. The "crop" ends of the old rails were used as bank bars and spacers. It was thus possible for tunnel driving to continue without interruption, although at times stocks of arches were very low; 8300 tons of steel were used in the form of arches and laggings. A length of 770 yard in the Huncoat and Rising Bridge section passed through old colliery workings, which were mostly in a collapsed state; this called for additional precautions against sudden gushes of gas and water, and for special care in driving and in supporting the ground.

In soft ground, support was given by 9ft 6in or 10ft 6in internal diameter reinforced concrete segments; and a short length of segment supported tunnel between Brynbella shaft and the River Irwell was driven under compressed air. Spoil was removed in trains of 10 wagons, hauled by 3- to 4-ton electric battery locomotives. Ventilation was effected by ten 90 h.p. reversible blower-extractors through 48,000ft of site-fabricated 15in diameter flanged ducting.

Considerable inflows of water were met, the heaviest being in the Townsendfold South drive, where the maximum flow was in the region of 60,000 g.p.h. A concentrated inflow of about 27,000 g.p.h. was intercepted in the drive north from the Bury portal.

Lining with Concrete.—Lining was deferred until the completion of the whole of the driving and sub-floor concrete. Crushed gravel and sand were imported by road from South Derbyshire, and cement and "fly-ash" were delivered in bulk by lorry.

An automatic weigh-batching plant was installed at Townsendfold, designed for a peak output of 60 batches per hour. The materials were batched dry in ½ cubic yard batches which were discharged into 25 cubic foot capacity side-tipping wagons and transported unmixed to the mobile mixing and placing plant near the shuttering in the tunnel. A maximum of 17 trains of nine wagons was in use, and, to avoid difficulties of shunting and passing, double 2ft gauge tracks were laid on the sub-invert concrete mat with a "California" crossing near the mixer. When placing commenced at the Huncoat (north) portal the round trip between batching plant and placer was 11 miles.

A 240ft length of circular steel shuttering, approximately similar in design to that used on the Bowland Forest tunnel, was used; and placing of the whole full-circle lining was continuous, using a pneumatic placer of French manufacture. All concrete was mixed adjoining the shutter in a specially made ½ cubic yard double-drum mixer, which was fed as necessary with batches of dry materials from the side-tipping wagons by means of a 30in belt conveyor.

Concreting commenced in September 1952, and was completed by May 1954—21 months. During the cement shortage 6 to 10 per cent saving in cement was effected by replacing part of the cement by "fly-ash," which produced a more easily workable concrete.

Grouting.—Careful "pattern grouting" was carried out to consolidate the broken ground below the tunnels, along the whole length of the section through the abandoned coal workings. In addition, extensive grouting was done to fill in all cavities between the tunnelling and the rock, to tighten up any cracks at construction joints and to seal off water inflows. The total cement and fly-ash injected was 11,760 tons, i.e. 4 cwt per linear foot of tunnel.

Cost.—The total cost of the Rossendale tunnels, including the River Irwell crossing and 721 yards of "cut-and-cover" conduits at the ends, is approximately £3·1 million. The contract basis was "value cost (with target)."

Marl Hill Tunnel

This tunnel connects the siphons crossing the Hodder and Ribble valleys, and comprises nearly 2½ miles of tunnel. The tunnel was driven from both portals, and the initial drives were through soft material, precast concrete rings being erected for ground support in 35 per cent of the tunnel length. The intermediate lengths were in hard rock, and were driven to a "horse-shoe" section, 60 per cent necessitated steel arch supports and the remaining 5 per cent were unsupported.

Northern Section Tunnels

The following tunnels were constructed on the northern section of the aqueduct: Coalbank (587ft), Docker (3690ft), Hallbank No. 1 (362ft), and Hallbank No. 2 (2604ft); total length, 1·37 miles.

Constructional methods on the Hallbank No. 2 and the Docker tunnels differed considerably from those adopted for the long tunnels described earlier.

The Hallbank No. 2 tunnel, driven mainly through boulder clay, was lined with reinforced concrete segments and driven with a shield of unit construction with a removable cutting edge. The shield was advanced by means of nine hydraulic jacks bearing on the last reinforced concrete ring erected.

On one section of the tunnel, rock in the lower half caused considerable delay and increased to a point where a full rock face was being worked. It was decided to leave the shield in position and to drive a slightly larger tunnel to enable the shield to be taken forward when boulder clay was again reached. After driving about 100ft the rock became unsafe, and it was necessary to drive again under the protection of the shield, and from this point the rock fell away rapidly as anticipated.

In general, the boulder clay was exceptionally stiff, and light blasting was permitted, the shield being covered with torpedo netting and with mild steel protecting plates fitted over all vulnerable parts.

Full-circle lining was carried out as a continuous operation, using a pneumatic placer and a 135ft length of the tunnel shutter previously used on the Rossendale tunnels.

A concrete mixer and placer were incorporated at the leading end of the shutter and were moved forward with it. The materials were batched dry outside the tunnel and transported to the working point in special hopper skips where the contents were then tipped into the mixer drum. After mixing in the tilting drum mixer the concrete was conveyed to the placing point by a pneumatic placer.

The driving of the Docker tunnel was difficult in the initial stages, as a belt of water-bearing gravel and clay was encountered, which necessitated driving with compressed air. Eventually a full face of rock was obtained 500ft from the portal, which persisted for the remainder of the tunnel, and enabled good progress to be made. The rock, Kirkby Moor flagstone, proved very stable, and steel supporting ribs were only used over a total length of 300ft. Lining of the tunnel was carried out by using a self-propelling type of shutter to enable concreting to be carried out continuously. The main body of the shutter was 30ft in length.

Initially, great difficulty was experienced in producing a reasonably homogeneous and continuous lining, and it became necessary to use, on top of the shutter, thin sheets of mild steel curved to the radius of the shutter. It was found that the position of the end of the placer pipe had considerable influence on the quality of the lining, but entirely satisfactory results were obtained when the end of the pipe was 12in from the concrete.

The results of using the self-propelling shutter, whilst falling short of expectations, were reasonably satisfactory in the rock section of the tunnel, but the lining of the short section at the south end of the tunnel, where the ground was supported by 9ft 6in reinforced concrete precast segments proved more difficult owing to restricted headroom and working space.

The forward movement of the self-propelling shutter was obtained by the use of an anchor ring situated at the rear end, hydraulic rams being used to drive the shutter forward. Initially, the anchor consisted of a series of inflated rubber bags mounted on a steel frame and protected externally by rubber and canvas sheathing; the friction between the pads and the concrete lining was used to resist the thrust when moving the shutter forward.

Serious delays were caused by the bursting of the rubber bags, and eventually a timber anchor ring, which could be held against the tunnel face by wedge action, was substituted; it proved to be much more practical.

The leading end of the main shutter body was sloped back at 45 deg. and baffle plates were fixed around the lower circumference to hold the concrete back. It was, however, necessary to use additional timber baffles from time to time to the extent of the overbreak at the side of the tunnel.

Concrete Single-Pipe Siphons with Continuous Steel Core

On some of the shorter siphons where the maximum head does not exceed 100ft, instead of laying the first of four steel pipelines, a single line only has been constructed, capable of conveying the maximum ultimate flow down the aqueduct.

The single pipelines consist of continuous steel cores lined with cement mortar ¾in thick and surrounded with concrete *in situ*. They have been adopted for four siphons on the northern section, totalling 3½ miles. The available fall requires a pipe 96in in diameter for the Watchgate siphon, and 87in in diameter for the other three siphons—Beela, Shaw Well and Park Beck.

The cores were made from ¼in steel plates and were formed into half cores, i.e. half cylindrical sections, at the maker's works, thus enabling them to be "nested" for transport. At the site the half cores were welded in a jig into continuous cores 12ft long.

After the trench had been excavated to the desired cross-section and level, the complete cores were laid on small concrete stools and the spigot ends entered into the swaged end of the core previously laid. The cores were then welded internally at the circumferential joints into a continuous pipeline. The trench excavation was carried out by dragline equipment.

The thickness of the concrete surround varied according to ground conditions, e.g. different cross-sections were used for trenches in rock and in soft ground, and also for certain sections of the siphons carried on piers partly above ground, &c.

Air valves and discharge pipes were normally placed as in standard pipeline practice; but in places where the hydraulic gradient permitted, protected air-vent pipes were used instead of the normal type of air valve.

At one depression on the line of the Watchgate siphon there was no suitable outlet available for a discharge pipe, and to overcome this difficulty a 9in diameter pipe was laid at the side of the main trench to carry the discharge from this length of siphon. The 9in pipe re-enters the siphon at a lower level farther down the line, and acts as a true siphon over the intervening rise, thus enabling water to be drained off from the next discharge outlet.

For producing the concrete, portable weigh-batchers and 21/14 high-discharge mixers were set up at convenient points from which the concrete was transported to the working point by diesel-engine dumpers, the normal "pan" being replaced by a concrete skip. At the working site the skip was lifted by a crane at the trench side and swung over the discharge point; and when not required for concreting the crane was used for placing the cores in position in the trench. The concrete was placed in lengths up to a maximum of 75ft per day, a wooden stunt-end being placed at the end of each day's pour. It was necessary to strut cores internally before concreting because of deformation during handling, storage, &c.

Lining of Steel Cores.—The steel-cored concrete siphons were completed by applying a cement mortar lining, using the "Centriline" centrifugal process. The equipment was of United States manufacture and comprised a 10 cubic feet capacity mortar mixer, a storage hopper mounted on a rubber-tyred bogie to transport the mortar, a centrifugal "sprayer," and a mobile generator for the supply of electricity for all purposes. The principal feature of this lining process is the high-velocity projection of the cement mortar on to the surface to be lined.

A thickness of ¾in of mortar was applied to the cores in one operation. Tests on a 1in lining showed a tendency for the material at the soffit of the arch to collapse in long lengths. The rate of longitudinal travel of the machine was set by trial and error to give the correct thickness of lining, as measured by special gauge at approximately " 10 o'clock " and " 2 o'clock " on the cores ; and for various reasons the thickness was slightly greater at the invert.

The maximum rate of lining was 60ft per hour for a ¾in lining on 7ft 6in internal diameter cores, and the greatest length lined was 720ft in one day of sixteen working hours. Access openings 6ft by 4ft had been left in the external concrete at intervals of about 700ft, and the machines were lowered through them into the siphon. The mixer was set up over the access openings and manholes.

Further protection was given by two coats of bituminous paint sprayed on to the whole of the concrete lining.

Covered Concrete Conduits (" Cut-and-Cover ").

This form of construction has an internal diameter of 8ft 6in and a gradient of 1 in 3000, and occurs chiefly on the northern section, where there is an aggregate length of 3·8 miles of " cut-and-cover " in the 11½ miles of aqueduct immediately south of Garnett Bridge. The following description applies particularly to work on the northern section. Constructional operations were very similar to those for steel-cored concrete siphons, except that collapsible steel shutters in 10ft lengths were used, and that when forming bends special short taper-pieces were fixed between adjacent shutters, to give a radius of curvature of about 170ft.

Where the conduit was located above the bed of a stream, crossings of varying span were necessary. In such cases the aqueduct was supported by continuous reinforced-concrete beams spanning the concrete abutments.

At the south end of the Rossendale tunnels an elevated conduit was constructed across a small valley for a distance of about 130 lineal yards, and here the conduit was carried by two longitudinal side wall supports. Spoil from the tunnel was placed between and around these supporting walls, and eventually was filled around the conduit to cover it completely.

Adjacent to the Marl Hill tunnel there is a length of about 565 yards of " cut-and-cover," mostly at the northern end, with construction joints at 20ft intervals. This section also includes a reinforced length over a culvert, and a reinforced barrel over a stream crossing 25ft wide.

Steel Multi-Pipe Siphons

There are five steel multi-pipe siphons : Mealbank, Greenbank, Lunesdale, Hodder and Ribblesdale, which ultimately will consist of four lines ; the Roch and the Audenshaw siphons will have two lines only. The first steel pipeline is 48in in internal diameter, lined with ½in of bitumen and sheathed externally with about $\frac{5}{16}$in thickness of fibre-glass, impregnated with bitumen. The spigot-and-socketed pipes are normally about 29ft 6in in length, with welded joints, except where it was desirable to introduce special flexibility, when an appropriate proportion of pipes, jointed at each end with Johnson couplings, was interspaced.

The spigot-and-socket joints were welded by three internal " runs " with a single external sealing-run ; they were then tested to 350 lb per square inch by a portable hydraulic pump. The lining and sheathing was then made continuous in the usual manner.

On the short Hodder siphon, for the purpose of providing much needed information on the relative merits and disadvantages of concrete lining and bitumen lining under identical conditions, the first line was lined *in situ* with a ¾in thickness of cement mortar, applied by the " Centriline " centrifugal process. The cement mortar lining was subsequently sprayed with two coats of bitumen paint, as a protection from attack by the soft moorland water.

Railway Crossings.—Except at Wennington, where ground contours favoured a self-supporting pipe " over-line " bridge, all railway crossings were made by first constructing a pipe subway formed by reinforced concrete segments " under line " of approximately 6ft diameter. After laying the pipe through the centre of the subway, and welding the joints, the annular space was filled with concrete. Apart from flow control arrangements, which are described specially later, the features of the remainder of the steel pipelines conformed to established modern practice.

At each north or inlet well a motor-operated penstock is bolted to the inlet end of the pipeline, and at each south or outlet well a single multi-flap non-return valve is bolted to the outlet end of the pipeline. Provision has been made at both the north and south wells for the insertion of stop planks to enable the penstocks and valves to be isolated for inspection and repair.

Motor-operated sluice valves, 30in in diameter, have been provided with taper pipes to divide each of the long siphons—Ribblesdale (10·3 miles) and Lunesdale (11·7 miles)—into four sections of approximately equal length. Cross-connections and 24in diameter valves have been provided upstream and downstream of each 30in diameter line stop valve, to enable sections of future pipelines to be put into service as completed and to maintain maximum capacity when it is necessary to put any section of pipeline out of service.

The type of automatic valve commonly used on pipelines depends for its functioning on an increase of velocity at the valve. It can be made to be responsive to small leakages that occur near the valve, but it has the inherent drawback of being much less sensitive to leaks that occur towards the end of the pipeline.

On the Haweswater aqueduct Venturi throats have been inserted in each pipeline near each north and south well, to operate in conjunction with the taper pipes and " throats " at the 30in diameter line valves ; and a multi-core electric cable laid alongside the pipeline enables flow measurements to be transmitted electronically between adjacent Venturi throats.

There are differential meters at all the penstocks and sluice valves on automatic control, which show the difference in flow between any individual valve and those immediately upstream and downstream. The differential meter indicates zero under normal conditions of no leakage, unless a bulk supply is being taken off the pipeline.

The automatic gear can be set to respond to any desired degree of leakage, and it will be equally responsive to a leak in any position along the pipeline.

Advantage has been taken of the provision of the electric cable for flow control to include wires to provide private telephone communication between the valve houses on a siphon.

There are side weir overflows at each north well, with a concrete pipeline of ample capacity to discharge any water becoming surplus on the closing-down of a valve, to the nearest stream or other suitable point of discharge.

Pipe Bridges

Over most river and stream crossings the pipes were laid below the bed of the stream and surrounded by concrete. There were, however, the following exceptions : the crossings over the Rivers Mint, Ribble, Lune, Calder, Hodder, and Roch, and the Hyndburn Brook.

Self-supporting steel pipes were used to span the two last-named rivers and the Leeds and Liverpool Canal, and a reinforced concrete arch slab bridge was constructed across the River Mint.

The Ribble and Lune Bridges.—Identical designs were used for these bridges, each of which consists of five similar reinforced concrete continuous beams of varying depth to give a three-arch profile with 50ft end spans and a centre span of 100ft.

Precast reinforced concrete hinges are embodied in the south pier, and the north pier carries a heavily reinforced precast concrete rocker.

On the abutments composite plates of steel and copper are located on the concrete to act as bearing plates for the bridge beams. The overall width of the bridge is 34ft and there are cross beams between the main ribs to carry the pipes and to act as stiffeners.

The 48in diameter pipes on the bridges are 15ft long and are strapped at their centres to the cross beams. The pipe joints are Johnson couplings, and expansion sleeves have been provided near the abutments.

No special foundation difficulties were experienced on the Lune site, but at the Ribble it was necessary to use reinforced concrete pile foundations for both north and south piers. Piers were constructed by forming steel sheet pile cofferdams and excavating through soft clay to a depth of 10ft below the river bed. The average penetration of the reinforced concrete piles below this level was 13ft 6in.

The sheet piles were driven as far as possible and the portions above the river bed were cut off with underwater cutters.

At each site a 5-ton electrical power derrick with a 120ft jib was erected in the river on a temporary piled foundation, to command nearly the whole of the site and the arch centering was supported by temporary timber piles driven into the river bed.

The abutments were faced with sandstone, which was also used for the coping of the parapet walls.

The external faces of the outer ribs and parapet walls were surfaced with a rubbed Cullamix " Tyrolean " finish of buff colour.

The Hodder and Calder Bridges.—It was also possible to adopt identical designs for these bridges, which were designed at a time when the steel shortage was very acute, and it was, in consequence, decided to adopt prestressed concrete.

Each bridge is designed for a clear span of 90ft, with mass concrete masonry-faced abutments to carry four lines of 48in diameter pipes, and consists of five freely supported main beams at 9ft centres, with the pipes carried between them on transverse beams. The main beams are made from precast concrete sections, generally 9ft 6in long and prestressed after assembly. Prestressing wires are in diaphragms 12in thick, placed between the separate sections. The maximum compressive stress in the concrete is 1800 lb per square inch and the maximum tensile stress in the wire is 120,000 lb per square inch.

Contractors and Main Contracts

The following principal contractors were responsible for the main construction works, as indicated below :—

Edmund Nuttall, Sons and Co. (London), Ltd., London : Docker, Coalbank, and Hallbank tunnels ; Watchgate, Park Beck, Beela, and Shaw Well single-pipe siphons ; New Hutton, Hallbank, Swarther, and Stangana conduits ; Mealbank and Greenbank steel-pipe siphons; bridge over River Mint; Haslington and Walmersley tunnels. The Cementation Co., Ltd., Doncaster and London : Bowland Forest tunnel. A. Waddington and Son, Ltd., London: Marl Hill tunnel; Hodder steel-pipe siphon. Earth and General Contracts, Ltd., Chorley and London : Lunesdale steel-pipe siphon. Harry Fairclough, Ltd., Warrington : Bridges over River Lune and River Ribble. Harry Wimpenny and Sons, Ltd., Prestwich : Bridges over River Hodder and River Calder. J. Blakeborough and Sons, Ltd., Brighouse : Supply of automatic valves, air valves, &c. The South Durham Steel and Iron Co., Ltd., Stockton-on-Tees : Supply of bitumen-lined and sheathed steel pipes and specials. British Insulated Callender's Construction Co., Ltd., Helsby : Supply and laying of electric cables. G. and J. Seddon, Ltd., Little Hulton : Construction of inlet well house, Heaton Park reservoir. Manchester Corporation Waterworks, Direct Works Section : Ribblesdale, Roch, and Audenshaw steel pipe siphons.

Land Anchor.—We have received from Summerson's Foundries, Ltd., Mowden Hall, Darlington, information about a new portable land anchor made by the firm. The anchor is of steel, aluminium coated, and may be of " V " or " X " shape. It is secured by four hardened spikes and will resist a pull of 6 tons.

Large Hollow Forged Boiler Drum.—What is stated to be the largest capacity hollow forged boiler drum ever made as a one-piece forging has been delivered from the Sheffield works of the English Steel Corporation, Ltd., to the Central Electricity Authority's new power station at Willington, near Derby, where it will form part of the second 100MW boiler unit to be installed in this country. This drum was made for International Combustion, Ltd., and weighs approximately 79 tons. It is 44ft from end to end, with walls 5 $\frac{7}{16}$in thick, and has an external diameter of 6ft 4¾in. The drum is designed for a pressure of 1870 lb per square inch but has successfully undergone pressure tests of up to 2855 lb per square inch. It is the first of a set of four similar drums and was made from a 275-ton ingot, the heaviest ever cast in the British Commonwealth. The ingot was 29ft high and 9ft in body section, and required six weeks' annealing before the top and bottom " discards " could be removed and a hole trepanned through the centre to produce the 190-ton billet needed to make the forging. The forging operation on the drum itself required fourteen " heats " in all and the whole operation took two-and-a-half weeks.

Colorado-Big Thompson Project

BY OUR AMERICAN EDITOR

No. I

For the past fifteen years the Colorado-Big Thompson scheme of the U.S. Bureau of Reclamation has been the major civil engineering work under construction in Northern Colorado. The scheme is now almost completed and, in fact, functioned last summer to save irrigated lands from crop failure due to drought. It gathers waters on the western slope of the Rocky Mountains and diverts them through a 13-mile long tunnel underneath the Continental Divide to the eastern slope, there supplementing the irrigation water supply. The potential of the water is used in several power stations to generate approximately 600 million kWh annually.

THE Colorado-Big Thompson project of the U.S. Bureau of Reclamation is a multiple-purpose scheme whose primary function is the trans-mountain diversion of surplus water from the headwaters of the Colorado River to supplement the present inadequate irrigation supply for about 700,000 acres of irrigable land in north-eastern Colorado. The scheme takes its name from the fact that Colorado River water from the western slope is moved through a tunnel under the Rocky Mountains into the Big Thompson River on the eastern slope. An estimated average quantity of 310,000 acre-feet of water a year is available for diversion from a point east of Grand Lake near the head of the Colorado River, yet such diversion, with the replacement storage provided, will not encroach upon the present or future irrigation requirement of the western slope lands in Colorado. This dependable supplemental supply will bring about a greater economic stability in the region through reduction in drought hazards, more abundant crops, and increased farm income. The secondary purpose of the scheme is to utilise the potential created by the water as it falls approximately 2800ft in the course of diversion. It is estimated that about 600 million kWh of firm electrical energy can be produced annually. The scheme involved an expenditure of about 170 million dollars.

As indicated in the accompanying map and profile diagram, the general plan for the operation of the scheme is as follows: surplus water originating on the headwaters of the Colorado River on the western slope of the Continental Divide is stored in the Granby reservoir. By means of the Granby pumping plant and pump canal water is lifted a maximum of 181ft and delivered to Shadow Mountain Lake—an extension of Grand Lake, which is a natural hydraulic feature. The water then flows by gravity from Grand Lake through the Alva B. Adams tunnel, under the Continental Divide to the eastern slope, where it passes through a series of penstocks and power plants and ultimately is stored in the Horsetooth and Carter Lake reservoirs. During the irrigation season water is released from these reservoirs to the Cache La Poudre, Big Thompson and Little Thompson rivers, and the St. Vrain Creek, to be rediverted through existing irrigation canal systems to lands lying within the Northern Colorado conservancy district. The general plan also includes replacement facilities to safeguard the water users along the Colorado River in Colorado against any infringement of their prior rights by the water diversions to the eastern slope. Hydro-electric generating installations having a total capacity of about 170MW are provided in the plan, and, in addition, switch yards, transmission lines and substations have been constructed to deliver the generated energy to the power grid area. The water supply of several Northern Colorado municipalities will be supplemented through the use of imported water, and additional benefits will accrue to the region through development of recreational facilities in accordance with the plans of the U.S. National Park Service and Fish and Wildlife Service.

Historical Background

In 1820 a U.S. Government exploring expedition commanded by Major Stephen H. Long described the land now being served by the works of the Colorado-Big Thompson project as "Almost wholly unfit for cultivation and, of course, uninhabitable by a people depending on agriculture for their subsistence. . . Though the soil is in some places fertile, the want of timber, of navigable streams, and water for the necessities of life, render it an unfit residence for any but a nomad population. . ." Irrigation was started in North-Eastern Colorado about 1860 by individual farmers using adjacent streams and crude ditches, but it was not long

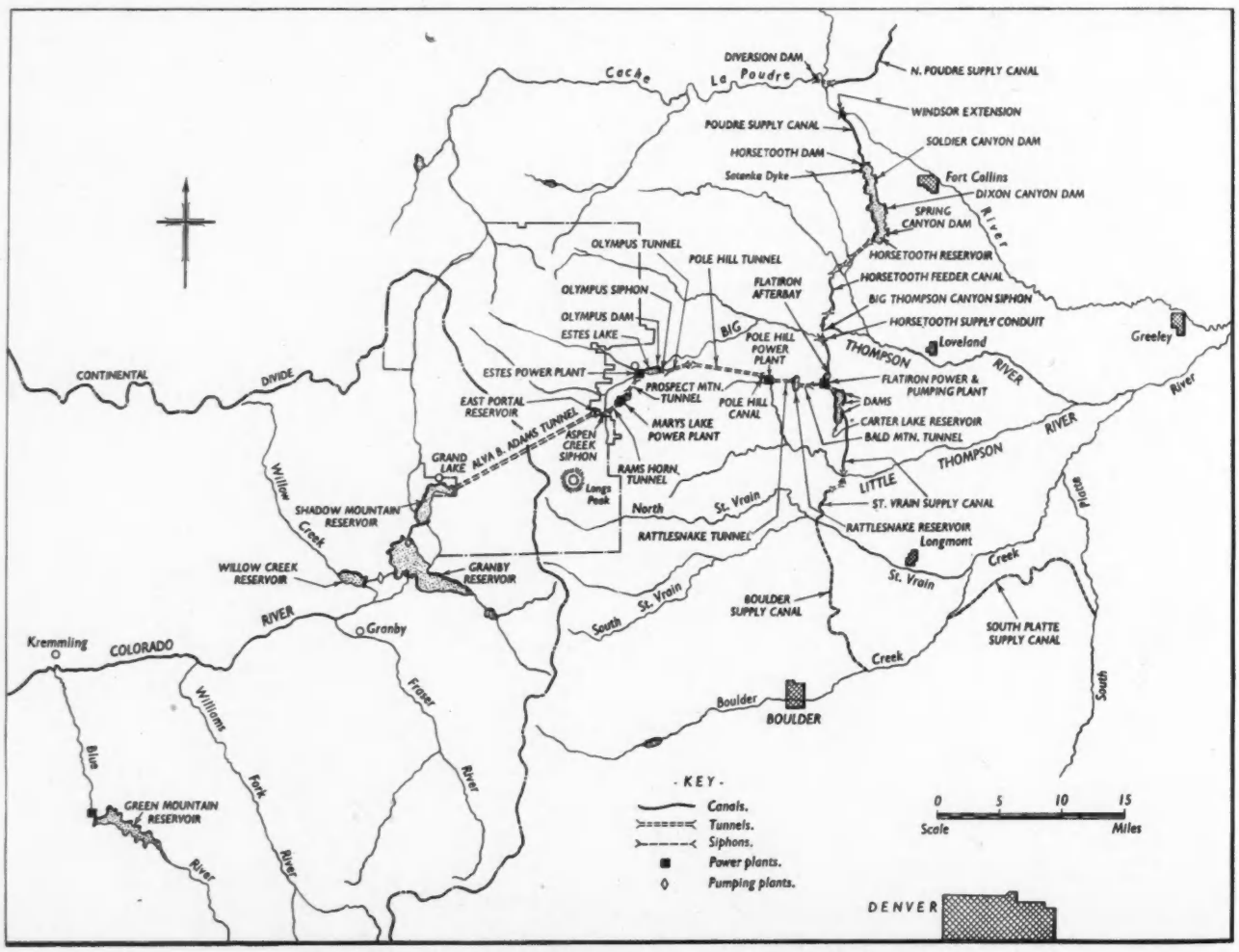


Fig. 1—Map of the Colorado Big-Thompson trans-mountain water diversion scheme

before the easily available potential irrigation water sources were depleted. By 1889 it was evident that irrigation water would have to be imported if the area was to continue its growth, and the Colorado Legislature appropriated 25,000 dollars for the investigation of trans-mountain diversions. Investigation indicated that under any plan of diversion an extensive tunnel would be necessary. Progressive steps in legislation finally led, in 1922, to the signing of the Colorado River Compact, which apportioned 7,500,000 acre feet annually to the upper basin States comprising Wyoming, Colorado, Utah, and New Mexico. Later, the Boulder Canyon Act provided funds for determining the amount of lands that were or could be irrigated in the Colorado River basin. Information obtained from these studies revealed that insufficient irrigable lands existed in the Colorado River basin to utilise all of the water provided in the compact. It was therefore only natural to conceive a plan whereby surplus Colorado River waters could be diverted into other watersheds in North-Eastern Colorado, where there was a surplus of irrigable lands and a shortage of water.

In August, 1935, the Bureau of Reclamation was allotted 150,000 dollars of Public Works Administration funds for surveys and investigations of a trans-mountain scheme to divert water from the Colorado River basin on the western slope of the Continental Divide to the eastern slope. After more than two years of extensive study a plan was developed which contained works for diverting the irrigation water from the western to the eastern slope, works for controlling western slope flows so as to guarantee existing water rights in the Colorado River basin, and works to take advantage of natural opportunities to develop hydro-electric power. The project plan was reviewed by many consulting engineers, the National Resources Committee, the committee on irrigation and reclamation of the U.S. Senate, the U.S. Department of Agriculture, the Colorado State Planning Commission, and other Federal, State and local agencies. These groups all agreed that the plan was both meritorious and necessary. The project was authorised in 1937 by two separate actions, one by the Congress, the other by the President of the United States. Detailed planning studies were continued while construction was in progress. The resulting information led to beneficial modifications of the original project plan. Some reservoir capacities were changed, other reservoirs were added to or dropped from the plan, part of the eastern slope routing was changed, and further power generating installations were added.

Water Storage Works

The Colorado - Big Thompson project comprises thirteen reservoirs, twenty-three earth and rock-fill dams and dykes, and five hydro-electric power plants connected by eight tunnels, two siphons, ten canals and three pumping plants, all situated within the borders of the State of Colorado. Arranged in an approximate order of their natural sequence, with respect to the flow of water from source to destination, the works of the project may be described as follows :

(1) The Western slope replacement storage system provides for the storage of surplus water in the Green Mountain reservoir on the Blue River for release at appropriate times to avoid any interference of the trans-mountain diversions with existing water rights on the Colorado River. The official Act passed by the U.S. Senate to authorise the scheme specified that 52,000 acre-feet of the total reservoir storage capacity of 154,600 acre-feet be reserved exclusively for replacement purposes. Any releases from the reservoir are utilised for the production of electrical energy.

(2) The Colorado River collection and storage system provides facilities for the collection and delivery of waters to the Grand Lake for diversion to the eastern slope. The Granby reservoir is the main storage reservoir for the Colorado River water. Willow Creek water is diverted to the Granby reservoir by means of the Willow Creek pumping plant and pump canal from the Willow Creek reservoir, which is used to divert the flow in the Willow Creek. The Granby pumping plant lifts water from the Granby reservoir to the Granby pump canal, which carries the water to the Shadow Mountain Lake. The Shadow Mountain Lake, which is formed by the Shadow Mountain dam on the North fork of the Colorado River, has a common operating level with the Grand Lake, and the level of this combined lake is maintained by pumping from the Granby reservoir when normal inflow is inadequate to meet the diversion.

(3) The Alva B. Adams tunnel, which is 9ft 9in in diameter and 13·07 miles long, carries the diverted water under the Continental Divide. This is the longest irrigation tunnel in the United States ever constructed from only two headings. This free-flow tunnel has a rated capacity of 550 cusecs and is concrete-lined throughout. A gas-filled, pipe-enclosed electric cable suspended from the tunnel arch above the normal water surface connects the eastern and western slope 69kV transmission circuits. The inflow of water into the tunnel is controlled in the gatehouse at the west portal by two 9ft by 10ft radial gates.

(4) The Estes Park aqueduct and power system receives flow from the Adams tunnel at the east portal and transports the water eastward over a distance of 5½ miles, utilising the 770ft of fall for the production of 53,100kW of electrical energy. While flowing from the Adams tunnel to the Marys Lake reservoir, the water passes through the Aspen Creek siphon, the Rams Horn tunnel and the Marys Lake power plant. Between the Marys Lake reservoir and Lake Estes on the Big Thompson River, the water passes through the Prospect Mountain conduit and tunnel and the Estes power plant. The water may be released from Lake Estes either into the Big Thompson River or into the Estes Park-Foothills power system.

(5) The Estes Park Foothills power system receives water from Lake Estes and transports it 14 miles east to the Foothills storage and supply system. In transporting the water through 10·2 miles of tunnels, 0·8 mile of siphon, 0·5 mile of canal, 2·5 miles of penstock, and two power plants, the system utilises the 2000ft of fall between Lake Estes and the Flatiron station afterbay for power production.

(6) The Foothills storage and supply system, along the eastern foothills of the Rocky Mountains, transports the water from the afterbay of the Flatiron pumping and power plant and transports the water to several conveniently situated reservoirs for storage purposes. The water is then delivered to existing irrigation facilities as required. The system now extends nearly 40 miles in the north-south direction along the foothills of the Rocky Mountains above the plains area and serves irrigation facilities in the Little Thompson, St. Vrain, and Boulder Valleys to the south, and in the Big Thompson Poudre, and North Poudre Valleys to the north of Flat-

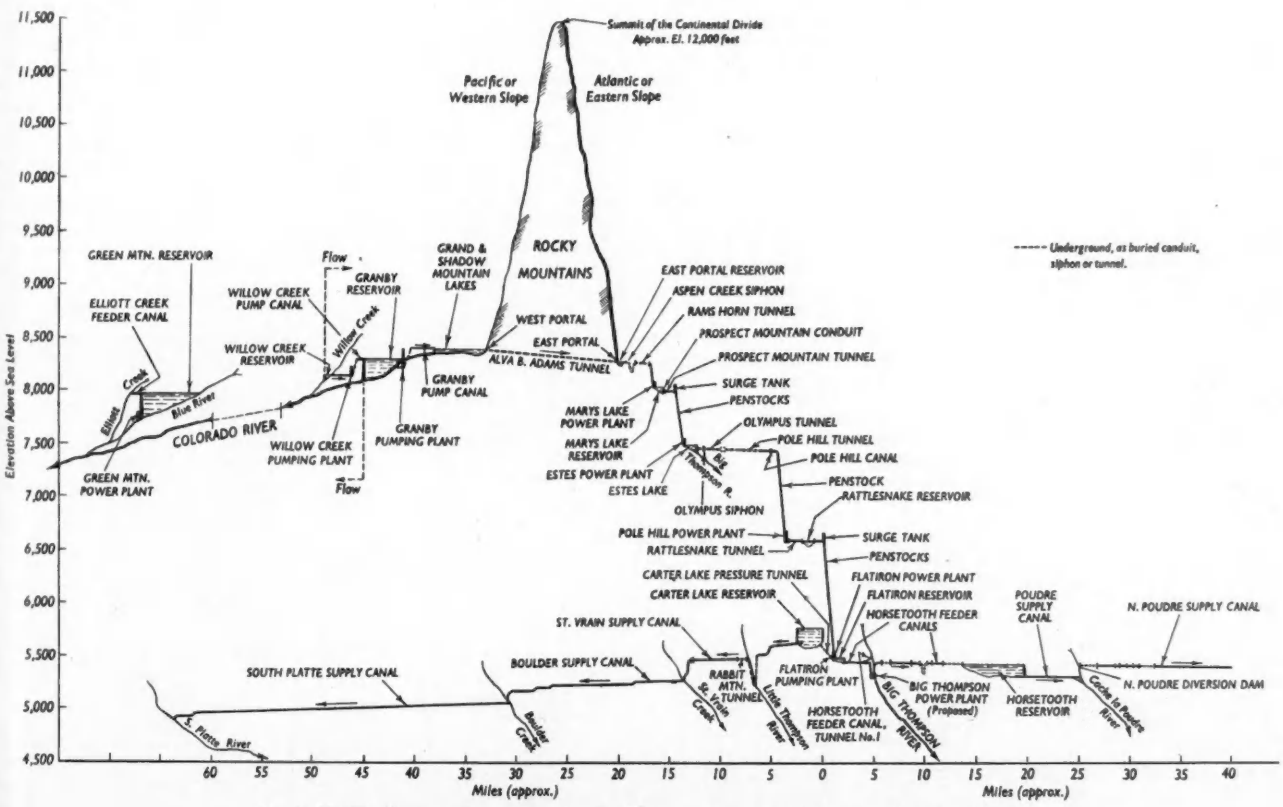


Fig. 2—Profile diagram of the Colorado - Big Thompson trans-mountain water diversion scheme

iron. The system includes the Flatiron pumping and power plant and the Carter Lake pressure tunnel, the Carter Lake reservoir, the St. Vrain supply canal, the Boulder supply canal, the Horsetooth feeder canal, and appurtenant supply conduit leading from the Big Thompson River, the Horsetooth reservoir, and the Dixon feeder, Poudre supply, and North Poudre supply canals.

In addition to the construction of hydro-electric plants and the production of energy from the operation of the scheme, the power development phase of the project includes the sale of energy to the market area. To ensure the availability of this energy, a grid system of transmission lines and substations has been built to connect the various power plants of the project with the load centres serving municipalities, communities, and co-operatives of the Rural Electrification Administration in Colorado and with other Bureau of Reclamation schemes in the neighbouring states of Wyoming and Nebraska.

(To be continued)

"Automation"

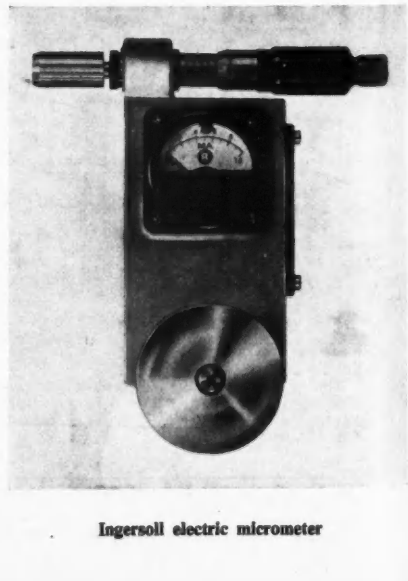
"AUTOMATION," as applied to engineering production, is very much in the news to-day and recently has become a hotly debated issue, particularly in trades union circles. At the annual meeting of the Institute of Radio Engineers in March, Dr. W. R. G. Baker, of The General Electric Company, maintained that automation can no more create unemployment than could mechanisation and declared that "the real socio-economic danger lies not in automation, but in those who are blind to its benefits and would brake its progress by inefficient make-work production methods." Last month the Michigan State College held a symposium entitled "Automation—Engineering for To-morrow," in which each particular engineering department of the college presented its own programme outlining the impact of automation on future design and construction. Perhaps most important, the post-war growth of automation in the United States has become such a major influence on production methods that it is believed to have been largely responsible for the current fight of the United Auto Workers' Union for the "guaranteed annual wage." The American unions admittedly have "got the shivers" over the prospect of factories that run without human hands, and the U.A.W. has based its demands for a guaranteed annual wage to a considerable extent on the imminence of further automation in its industry. The workers' representative openly admits that they consider the guaranteed annual wage as a means of affecting works management decisions concerning both the timing and the placement of new automation installations, so that those decisions will be tempered by a degree of social consciousness. Engineers now realise that so vast are the potentialities of our new control devices that it is possible to visualise acres of factory or office space in which no worker is needed. "Automated" equipment can process raw materials, assemble them into finished goods, package them and load them into lorries and wagons without direct human help. But that is not all. The "automated" machines can adjust to variable productive conditions, correct their own mistakes, inspect the finished product and even change their own parts when parts break or wear out. Little wonder that some engineers estimate that 70 per cent of all the machine tools now in use are outmoded. Already automation is being used in America to refine oil, make artillery shells, put together television sets, bake cakes, process chemicals, generate electric power, mail out insurance bills, put through trans-continental telephone calls and build automobile engines. In such operations a few engineers and one or two maintenance men are all the work force required. They spend most of their time watching the flashing lights and checking the dials on the control panels; the machine does the rest, even down to the point of letting them know when it needs human attention. Vending machines are being used to sell some of the goods that automation produces, but the human touch is still necessary to do most of the sales job, to say nothing of the buying. Even here automation has its foot in the door. Electronic tabulating equipment is being used to do the market research that tells a company where its customers are!

Automation opens up vistas of unparalleled abundance and comfort; at the same time, it stirs fears of mass unemployment and frustration. It promises a vast expansion in goods and services, sharp reductions in prices and increased opportunity for the enjoyment of leisure. It makes the three-day week-end a realisable goal; it offers emancipation from the drudgery of routine, repetitive tasks. But with these prospective blessings comes concern that liberation from drudgery also will mean liberation from any regular pay envelope for large numbers of workers. Unions are now demanding that the Federal Government take the lead in working out a retraining and adjustment programme to prevent widespread hardship from attending the dawn of this new industrial era. This same concern has led to the above-mentioned union campaigns for a guaranteed annual wage. By assuring a worker a full year's pay after he loses his job, the wage guarantee would help a man pay his bills while he sought another job at the work he knew or trained himself for a new type of employment. The basic fears aroused by automation are not new. A century and a half ago the advent of the industrial revolution stirred British and European workers to such excesses of anxiety that they hurled wooden shoes into automatic looms and smashed newly-installed machinery with sledge hammers. The battle of men against machines was carried to the United States and was a major factor in the rise of American trade unions. However, experience has taught labour leaders two things. One is that it is impossible to stop technological advances; the other is that it is contrary to the best interests of the workers themselves even to try. Over the long haul, labour shares with all other groups in the community the advantages of improved productive methods. This has been the root of the higher wages, shorter working hours and better living standards enjoyed by American workers.

Union leaders do not question that this general process of long-term improvement in living standards and expansion in job opportunities will accompany automation. What worries them is what happens along the road to the new economy of abundance. They note that the steel industry is turning out a third more steel than it did a year ago with no increase in the number of workers, and that the automobile industry is doing much the same. Government statistics at the end of last year indicated that all manufacturing industries were producing as much as they had a year earlier, even though the number of factory workers had dropped by nearly a million. For each man-hour of human labour the average factory turned out 7 per cent more in February of this year than in the same month of 1954. And all this with automation still only in its infancy. Population experts insist that this upsweep in productivity, going forward at double or triple the rate that has prevailed over the last half-century, comes at a happy time for the United States. Without it, they fear that the nation's problem will not be too many workers for the jobs available, but too few. They foresee a shortage in the next ten or twenty years of qualified workers—partly because the working population will reflect the abnormally low birth-rate of the depression years of the 'thirties, partly because people start working later and retire earlier and partly because the work week is likely to keep getting shorter. The National Manpower Council is convinced that the next few years will see a jump in the need for technicians and highly skilled workers, while unskilled workers will find fewer and fewer places to work. The council warns that electricians would have to learn electronics and pipe-fitters hydraulics if they wanted to keep in step with science. It is this increasing call for highly developed labour skills that has prompted the American Secretary of Labour to tell the country that its survival is menaced by the decline in work skills. Colleges and universities are giving increased attention to the requirements of the new industrial technology. This attention is not limited, however, to the need for more specialists in engineering and other specialised spheres. It also extends to preparing men and women in the humanities so that they will be better equipped to guide the complex industrial society along a constructive course, to think through industrial problems and to make effective use of the leisure time that will be opened up in the next decade. Even for technicians automation will bring some jolts. With robots giving orders to other robots and telling one another when they are wrong, the most skilled workers are likely to find themselves made superfluous by machines unless they have the adaptability to move to other and radically different assignments. At the General Electric works in Utica, for instance, automatic testing equipment was designed recently to check the reliability of military electronic devices. One girl with no technical training is able to run the new equipment. It took seven technicians with a high degree of specialisation and fourteen semi-skilled workers to do the same testing job before. All were put to work on other tasks in the Utica works. But even in this instance automation proved that it could be a job-builder as well as a job-destroyer. The company is considering the establishment of a new product line to turn out testing equipment that could be used by military forces in the field. Thus, automation would open up a new area of employment, at the same time leading to better diversification of the firm's range of products. On the whole, engineers have every reason to believe that with such increasing applications of automation, the future holds great promise for them. In 1900 an average of one engineer was employed for every 250 workers in America. In 1952 the ratio was down to sixty workers and in a company such as General Electric the ratio is now one engineer for every twenty workers. One can only hope that the remainder of the industrial family can successfully adapt themselves to the approaching changes and reach that "Brave New World" without undue dislocation.

Electric Micrometer for Checking Machine Alignment

THE accompanying illustration shows an interesting electric micrometer which has been introduced by the Ingersoll Milling Machine Company, of Rockford, Illinois, to simplify the alignment of heavy machinery, aircraft jigs, transfer machines and other heavy equipment. The micrometer is a precision instrument which was developed to provide a means for checking vertical alignment and lateral horizontal alignment over substantial distances where conventional micrometers cannot be used effectively. It is designed to give fast and accurate readings within 0·0002in, and can be operated by anyone familiar with a standard micrometer. The instrument is compact and sturdy, and is built to facilitate easy maintenance. Supplied with the micrometer are a magnetic-base platform and a C-clamp, which make it possible to mount the instrument almost anywhere and in any position. The instrument was originally developed for the company's own work in manufacturing special milling and boring machines.



Ingersoll electric micrometer

Industrial and Labour Notes

Strike on British Railways

The strike of locomotive men and motormen employed on British Railways, which has been called by the Associated Society of Locomotive Engineers and Firemen, began at midnight on Saturday last, May 28th. A small proportion of British Railways' locomotive staff are members of the National Union of Railwaymen, which union is not taking part in the strike, but although they have remained at work, it has not been possible for British Railways to run more than a few trains each day.

The Associated Society of Locomotive Engineers and Firemen has called the strike because of a dispute concerned with wage differentials. Its executive refused to agree to the railway wage revision which was made last January by the British Transport Commission and which was accepted by the National Union of Railwaymen and the Transport Salaried Staffs Association. The executive of A.S.L.E.F. had lodged a claim which, if met, would increase by amounts varying from 1s. 6d. to 5s. 6d. a week, the difference between the wages of footplate staff and other grades of railwaymen. The A.S.L.E.F. claim was examined by the Railway Staff National Tribunal, which represents the final stage in the accepted negotiating machinery, and the Tribunal's award recommended the acceptance of the British Transport Commission's proposals. The executive of A.S.L.E.F. rejected this award and instructed its members to strike on May 1st. After intervention by the Minister of Labour and the general council of the Trades Union Congress, however, A.S.L.E.F. agreed not to take strike action then but to take part in further talks with the British Transport Commission on the question of wage differentials. The executive of the National Union of Railwaymen also participated in these discussions. The Transport Commission put forward new proposals by which locomotive staff would be divided into two grades to take account of the varying degree of responsibility which their work involves, and wage increases commensurate with those degrees of responsibility were offered. But, again, the executive of A.S.L.E.F. refused to accept the Commission's proposals, and announced that the strike which had been "postponed" from May 1st would begin on May 28th. Up till a late hour last Saturday, the Minister of Labour and his conciliation officers, together with members of the T.U.C. general purposes committee did their utmost to find a formula which might lead to a peaceful settlement of the dispute. The executive of A.S.L.E.F., however, remained adamant in its view that satisfaction on the subject of differentials had not been reached and that, therefore, the strike by its members was "inevitable."

The British Transport Commission immediately put into effect plans for dealing with essential freight movement according to a system of priorities, and a committee of Ministers, under the chairmanship of the Home Secretary, has been supervising the maintenance of essential services. In a broadcast talk last Sunday, the Prime Minister, Sir Anthony Eden, spoke of the efforts which had been made to avert the strike. He went on to point out that although the dispute was between the Associated Society of Locomotive Engineers and Firemen and the British Transport Commission, the difficulties in the way of settling it had mainly been brought about by the differing points of view between the A.S.L.E.F. and the National Union of Railwaymen. The prospects for peace in the railway industry, the Prime Minister said, would be transformed if only those two unions would talk and work together. Sir Anthony emphasised the damage which must be caused by the strike. It would, he said, injure our country in a world which was becoming increasingly competitive. Supplies to factories would be affected at once, a circumstance which, the Prime Minister pointed out, must bring unemployment on a rapidly increasing scale to workers in no way involved in the dispute. On Tuesday evening it was announced that a State of Emergency had been proclaimed by the Queen, and that at a meeting of the Privy Council held at Balmoral, essential emergency regulations had been made.

Changes in Wage Rates

The Ministry of Labour has stated that changes in wage rates, which were reported to have come into operation in April in the United Kingdom, resulted in an aggregate increase of approximately £996,000 in the weekly full-time wages of 2,471,000 workpeople. Those receiving wage increases included workers in building, civil engineering contracting, coal mining, gas undertakings and waterworks, dock labourers, and the locomotive running staff of British Railways.

In building and civil engineering contracting there were increases, in April, of 2½d. an hour for craftsmen and of 1½d. an hour for labourers, and in coal mining new standard grade rates were established for day wage workers, which resulted in increases of varying amounts. The national minimum wage for dock labourers was increased by 2s. a day, and in gas undertakings the standard rates for men were increased by 4d. or 3d. an hour, according to occupation. The locomotive running staff of British Railways received increases ranging from 2s. 6d. to 6s. 6d. a week, according to occupation and period of service. These increases were retrospective to January and were part of the railway wage revision which was made in that month, and which has since been rejected by the Associated Society of Locomotive Engineers and Firemen. Other wage increases which came into effect in April included an addition of 3d. an hour to the consolidated rates of those employed in waterworks undertakings in England and Wales.

The Ministry of Labour says that in the first four completed months of this year changes in wage rates resulted in an aggregate increase of £3,455,500 in the weekly wages of about 9,019,500 workpeople. This amount included £1,091,600 to 2,442,000 people employed in the engineering, shipbuilding and allied industries following the wage increase agreed upon in March. In the first four months of last year, there was a net increase of £1,659,000 in the weekly full-time wages of 5,926,000 workpeople. The increases payable in April caused a rise of two points in the index of rates of wages (June 30, 1947=100). At the end of April, the index for all workers was 151, compared with 141 in April last year.

Industrial Disputes

During April there were 226 stoppages of work through industrial disputes reported to the Ministry of Labour as beginning in the month, and in addition there were twenty-seven stoppages which were already in progress. In these 253 stoppages of work, 67,900 people were involved directly and indirectly during April, with the result that 214,000 working days were lost. In the preceding month 149,000 working days were lost by 56,800 workers. The April figures included the major part of the stoppage of maintenance engineering workers and electricians in London daily newspaper printing establishments. There were 860 people directly involved in this strike, but in April there were 20,000 others who were not concerned with the strike but who had to cease work on account of it, the aggregate number of working days lost being 100,000.

In the latest issue of the *Ministry of Labour Gazette*, the statistics of stoppages of work through industrial disputes in 1954 are surveyed in some detail. There were 1989 stoppages of work reported last year, compared with 1746 in the preceding year. In addition, there were ten stoppages which began at the end of 1953 and were continued in the early days of last year. About 450,000 workpeople were involved last year in these 1999 stoppages of work, the aggregate number of working days lost being 2,457,000, compared with 2,184,000 days lost in 1953. The Ministry says that the number of workers involved in all the stoppages in progress during last year represented about 1·5 per cent of the total number of those in civil employment, and the loss of time for each of the workers involved averaged seven working days during the year. The biggest number of stoppages of work through industrial disputes last year occurred in the coal mining industry. These stoppages accounted for nearly one-fifth of the aggregate loss of time and for about two-fifths of the total number of workers involved in all stoppages in the year, showing that the majority of the coal mining stoppages were of relatively short duration. Among the other stoppages of work last year mentioned in the Ministry's survey is that which occurred in the ship repairing industry following a protest by electricians against the order of discharge on redundancy. It began about the middle of September and continued until early December, and involved about 8700 workers in various trades in London and the Thames estuary. Approximately 485,000 working days were lost. Stoppages of work last year in the transport industry accounted for nearly two-fifths of the aggregate loss of time. The introduction of additional lodging turns led to a stoppage of work by about 2700 locomotive drivers and firemen mainly in the Western Region of British Railways and resulted in a loss of 24,000 working days. The largest single stoppage of work last year was that involving about 26,000 dock workers employed in the Port of London and connected waterways. It originated over a dispute about meat sorting, but subsequently it was claimed that discussions should be resumed on various outstanding matters, and that overtime should be regarded as voluntary. This stoppage lasted from the end of September until the end of October and caused a loss of about 530,000 working days.

Investigating Absence from Work

The British Institute of Management has published a booklet entitled *Absence from Work—Recording and Analysis*, which sets out a system for compiling evidence on the incidence, cost and control of absence from work. The Institute says that until recently no full-scale attempt has been made to discover the rates of absence which may be considered reasonable and to provide a standard method which may be used for comparison between one company and another. Two years ago, therefore, the Institute began an investigation, the first step being to make a pilot survey to test methods of recording and analysis. The results of that part of the investigation are given in the booklet. The booklet also contains an invitation to undertakings to participate in a nation-wide survey which will indicate the extent of the absence problem and provide suggestions for some methods of control.

The booklet can be obtained from the British Institute of Management, 8, Hill Street, London, W.1, price 2s. 6d.

Transport Policy

Speaking at the annual meeting of Unilever, Ltd., last week, Sir Geoffrey Heyworth, the chairman, urged that transport efficiency was as important as manufacturing efficiency. It was strange, he said, that the world of transport, which should be one of mobility, was to a certain extent characterised by a rigidity of outlook and policy. In the main, Sir Geoffrey suggested, the origin of that rigidity was the unwillingness of the older forms of transport to accept the consequences of technological change and to meet the changing demands of industry. That tendency, Sir Geoffrey asserted, applied to management, labour and governments. Too often, he continued, even the trade unions had resisted labour-saving methods or had applied practices which vitiated their effects, while some authorities still maintained a bureaucratic approach to the economic problems of transport. Now that governments were committed to full employment in an era of expanding production, Sir Geoffrey said, the opportunity surely existed for labour, management and officialdom to do away with all the remnants of the old defensive attitude and to adjust themselves with open minds to the requirements not only of to-day, but of to-morrow as well. In transport, as in industry, a dynamic outlook was vital.

Personal and Business

Appointments

BALBARDIE, Ltd., Edinburgh, states that Mr. V. W. Scadding, the London manager, has been appointed a director.

THE ATLAS DIESEL COMPANY, Ltd., Wembley, announces the appointment of Mr. A. E. Morgan, A.M.I.Mech.E., as works manager.

MR. SEAN MACENTEE has been elected a director of Brush Aboe (Ireland), Ltd., which is the Irish subsidiary of The Brush Group, Ltd.

MR. A. GOODSELL, Mr. J. H. Orr, and Mr. G. S. Pound have been appointed directors of Coalite and Chemical Products, Ltd., Chesterfield, Derbyshire.

FOSTER ELECTRICAL SUPPLIES, Ltd., states that Mr. L. D. Gunnell, general sales manager, and Mr. H. G. Carter, secretary, have been appointed directors.

BLAW KNOX, Ltd., 94, Brompton Road, London, S.W.3, states that Mr. John Chaplin, A.M.I.Mech.E., has been appointed to the executive staff of the chemical plants department.

THE ELECTRIC CONSTRUCTION COMPANY, Ltd., announces the appointment of Mr. A. N. D. Kerr, A.M.I.E.E., as district engineer in Bristol, for the counties of Gloucester, Hereford and Somerset.

MR. DAVID I. KING has joined The United Steel Companies, Ltd., 17, Westbourne Road, Sheffield, 10, as technical press officer. He was formerly editor of *The British Steelmaker* and *The Master Builder*.

BIRLEC, Ltd., Tyburn Road, Erdington, Birmingham, 24, states that Mr. K. L. Moon has been appointed sales manager of the induction heating division and Mr. H. J. Podmore, sales manager of the specialist dryer division.

LONDON TRANSPORT states that Mr. R. M. Robbins, secretary to the Executive, has been appointed chief public relations officer in succession to Mr. D. McKenna, who recently became assistant general manager of the Southern Region of British Railways.

H. W. KEARNS AND CO., Ltd., Broadheath, near Manchester, states that Mr. H. J. D. Kearns has been appointed joint managing director. Mr. C. A. Sparkes, chief designer, has been appointed a director, having special charge of design and development work.

THE NATIONAL COAL BOARD states that Mr. D. M. Clement has been appointed deputy director-general of finance at headquarters in succession to Mr. A. W John, who became director-general in March. Mr C. G. Simpson has been appointed deputy director general of the Board's new staff department.

SHARPLES CENTRIFUGES, Ltd., Woodchester, Stroud, announces the appointment of Mr. R. T. Collins as senior project engineer in the Midlands, and of Mr. G. H. Duffield as senior project engineer in the North of England. Mr. M. W. Vincent has been appointed to the company's development staff at Woodchester.

BRIGADIER W. S. KING has been appointed to succeed Brigadier F. W. Gordon-Hall as director of inspection of fighting vehicles at the Ministry of Supply. Brigadier J. L. Morton will succeed Brigadier King as deputy chief engineer at the Fighting Vehicles Research and Development Establishment, Chertsey.

SAMUEL FOX AND CO., Ltd., Stocksbridge, Sheffield, announces the appointment of Mr. R. D. Pollard as director and chief metallurgist from July 1st. He will succeed Mr. G. R. Bolsover, director and consulting metallurgist, who is retiring. Mr. O. Inman is retiring from his position as director of developments, but he will continue to serve on the board of Samuel Fox and Co., Ltd.

Business Announcements

HIND CONSTRUCTIONS, Ltd., has changed its address to Industry House, 159, Churchgate Reclamation, Bombay, 1.

T. SMITTON AND CO., Ltd., has moved to Barclays Bank Buildings, Sheepcote Street, Birmingham, 15 (telephone, Midland 7301).

DONVIN INDUSTRIES, Ltd., has changed its address to Electrin Works, Winchester Street, Acton, London, W.3 (telephone, Acorn 4995).

MR. C. S. J. SUMMERLIN, managing director of Plysu Products, Ltd., Woburn Sands, Bucks, has just returned from a tour of Canada and the U.S.A.

D. NAPIER AND SON, Ltd., states that Mr. W. E. Hampton, its aviation export representative, left London on May 27th on the first stage of a world tour.

THE GENERAL ELECTRIC COMPANY, Ltd., has opened new headquarters for its sales organisation in Birmingham at Magnet House, Newhall Street, Birmingham.

THE DAVID BROWN group states that industrial tractors and ancillary equipment are now marketed in Eire by David Brown Tractors (Eire), Ltd., 25–29, Upper Dominick Street, Broadstone, Dublin.

THE CENTRAL ELECTRICITY AUTHORITY states that its commercial manager, Mr. E. R. Wilkinson, M.I.Mech.E., M.I.E.E., has completed his mission on behalf of the International Bank for Reconstruction and Development, and has now returned to this country.

THE EXPORT CREDITS GUARANTEE DEPARTMENT states that its Leeds office has been moved to Weetwood Chambers, 93a, Albion Street, Leeds, 1 (telephone, Leeds 30082). This office covers the area of North and East Yorkshire, excluding the towns of Middlesbrough, Redcar and Thornaby-on-Tees.

THE BRISTOL AEROPLANE COMPANY, Ltd., announces the retirement of Mr. C. W. Tinson, F.R.Ae.S., from the position of sales liaison engineer, after thirty-five years in its service, and of Mr. F. W. Whitehead, M.I.Mech.E., F.R.Ae.S., from the position of chief production engineer in the engine division, after thirty-four years' service.

BAKER PLATINUM, Ltd., Hanovia Products, Ltd., and Hanovia, Ltd., have joined to form a company entitled Engelhard Industries, Ltd. The three divisions of the company are as follows :—Baker Platinum Division Engelhard Industries, Ltd., 52, High Holborn, London, W.C.1 ; Hanovia Products Ceramics Division Engelhard Industries, Ltd., 146, Vauxhall Street, Kennington, London, S.E.11 ; Hanovia Lamps Division Engelhard Industries, Ltd., Bath Road, Slough, Bucks.

Miscellanea

MILK BOTTLING AND PROCESSING CENTRE.—The Express Dairy Company (London), Ltd., has drawn our attention to the fact that its new milk bottling and processing centre at Morden has a total daily capacity of 120,000 gallons of milk, and not 12,000 gallons as was stated in the description of the plant in our issue of May 20th.

ASSOCIATION OF PUBLIC LIGHTING ENGINEERS.—The annual conference of the Association of Public Lighting Engineers will be held at Folkestone from Tuesday to Friday, September 13th to 16th. During the period of the conference, there is to be a comprehensive exhibition of street lighting apparatus and equipment on a site in Langhorne Gardens, Folkestone.

PRESSURE RELIEF VALVE OF GLASS.—A pressure relief valve made of borosilicate glass is now made by Q.V.F., Ltd., Mill Street Stone, Staffs, for use in glass pipelines. The valve is made in two capacities suitable for maximum operating pressures of 5 lb and 30 lb per sq in, with 2in bore flanged pipe fitting and it is equivalent to 1in full bore in size. The lubrication is required for the valve seat and the load is applied by a weight which can be slid along a steel yardarm for calibration purposes.

SEA BOAT FOR ROYAL NAVY.—A new 27ft sea boat to be known as the Three-in-One Whaler is to be given trials in H.M.S. "Cumberland" this year. In the design an attempt has been made to meet three separate requirements, the primary function being that of a light motor sea boat capable of rescue work on the high seas and, secondly, to be capable of being sailed fast in regattas, while the third requirement is that it should be available as a pulling boat for recreational purposes.

FREQUENCY MODULATION DEMONSTRATION AT THE SCIENCE MUSEUM.—A demonstration has been arranged at the Science Museum, South Kensington, to explain to the public the B.B.C.'s new broadcasting service using frequency modulation on very high frequency waves. Comparative recordings will be demonstrated and the operation of a modern commercial F.M. broadcast receiver will be explained. The Science Museum is open on weekdays from 10 a.m. to 6 p.m., on Sundays from 2.30 p.m. to 6 p.m., admission free and the V.H.F., F.M. demonstrations will continue for about three months.

INTERNATIONAL CARGO HANDLING ASSOCIATION.—The International Cargo Handling Co-ordination Association announces the formation of a Spanish National Committee, the Council of which is composed of : President, Don Fernando Conde de Ponto ; Vice-President, Don Mateo Silvela Tordesillas ; Secretary, Don Carlos Angulo Garcia-Ogara; and the following members :—Don Ramon Gorbena Renobales, Don Enrique de Larragan y Gil Delgado, Don Pablo Suarez, Don Miquel Pintor, Don Gregorio Asteinza Larraendo, Don Ramon Montalban Garcia-Noblejas and Don Manuel Macias Alonso.

PLASTICS MATERIALS AND MACHINERY.—A new guide has been published by the British Plastics Federation entitled "Buyers' Guide to Plastics Materials and Machinery and Equipment for the Plastics Industry." The new edition of the guide has been considerably extended and includes particulars of materials in semi-processed forms such as sheet and tubing. There is also a completely new section dealing with machinery and equipment for the plastics industry. The names and addresses of the member companies supplying each kind of material and machinery are given and the trade names used shown. At the head of each section of materials there is a note giving the principal properties and the more important applications of the material concerned. The guide is obtainable from the British Plastics Federation, 47–48, Piccadilly, London, W.1, price 2s. 6d.

FIVE CENTURIES OF BRITISH TIMEKEEPING.—A horological exhibition entitled "Five Centuries of British Timekeeping" is to be held at the Goldsmiths Hall, Foster Lane, London, E.C.2, for one week beginning on October 3rd. It is being arranged by the British Clock and Watch Manufacturers Association, in collaboration with the British Horological Institute and the Worshipful Company of Clockmakers. It has been stated that the idea of this exhibition came from a meeting of the British Horological Institute at which the chairman of the Institute claimed that the industry's output last year totalled 3,000,000 watches and 5,000,000 clocks, and that 2,000,000 watches and clocks were exported.

MR. R. M. GILLIES.—We have learned with regret of the death, on May 25th, of Mr. Robert M. Gillies, who until his retirement in 1947 was London manager of G. and J. Weir, Ltd. Mr. Gillies, who was seventy-nine, served his apprenticeship with John Brown and Co., Ltd., at Clydebank, and after further experience in the firm's drawing office and as assistant to the engine works manager, he was employed at Portsmouth and Devonport Dockyards, and on the Tyne, installing machinery and carrying out trials in all classes of naval ships. During the 1914-1918 war Mr. Gillies was called to the Admiralty by Sir Thomas Bell to take charge of the engineering department for all ships except the heavy fighting ships. Mr. Gillies joined G. and J. Weir, Ltd., as London manager in February 1919, and was well known in shipping and engineering circles. He was a member of the Institute of Marine Engineers, the Institution of Naval Architects and the North East Coast Institution of Engineers and Shipbuilders.

COURSES IN CONCRETE PRACTICE.—The course in concrete practice established by the City and Guilds of London Institute in 1954 has now been extended into a second year for the benefit of those students who wish to gain a more advanced knowledge of the subject. The second year course is planned on the same basis as that for the first year, viz. one two-hour evening lecture per week for a period of twenty-four weeks, and will come into operation from the commencement of the college session, 1955/56. An examination, consisting of a written paper and an oral test, will be held in May, 1956, and certificates (Grade II) will be awarded to successful candidates. Students will normally be expected to have completed successfully the first year course before entering for the second year course. The courses are intended for supervision and potential supervision of concrete work on constructional sites. Full particulars of the course can be obtained from the City and Guilds of London Institute, Department of Technology, Gresham College, Basinghall Street, London, E.C.2, price 6d.

MOTOR YACHT "QUEEN A'LIA."—The work of re-engining and reconditioning the motor yacht "Queen A'Lia" was recently completed by John I. Thornycroft and Co., Ltd. This vessel was built in the United States in 1931 for Antarctic exploration work and was purchased by the Iraq Government in 1949 for the use of King Feisal. With an overall length of 195ft the vessel has a beam of 30ft, a draught of about 13ft 6in and a gross tonnage of 749. The original American propelling and auxiliary machinery has been replaced by British equipment. The new propelling machinery comprises two Crossley two-stroke, six-cylinder, direct-reversing engines, each developing 900 b.h.p. at 250 r.p.m. Each engine is directly coupled to outward-turning shafts fitted with 80in diameter, 7ft 10in mean pitch propellers. The auxiliary equipment includes new generating plant consisting of two 100kW, one 60kW and one 5kW sets. Two funnels previously fitted have been replaced by one funnel, which houses the exhaust silencers of the engines. The accommodation has been extensively rearranged, refurnished and redecorated, and a sun lounge with sliding doors built at the after end of the main deck.

CHECKING THE RUNNING TIME OF MACHINES.—An instrument known as the "Horameter" has recently been introduced by Target Services, 6–11, Dorset Close, Gloucester Place, London, N.W.1, for checking the running time of machines. This instrument is switched on whenever the associated machine is started and switched off whenever it is stopped, and it automatically records the number of running hours. If the machine is electrically operated, the "Horameter" is wired in parallel with the machine and both are simultaneously connected across the mains. For mechanically driven mechanisms, a switch operated by the machine is connected in series with the "Horameter" and a separate source of electric current can be provided in the form of a 6V dry battery. When current is applied, a small electromagnet in the instrument is energised and winds up a clockwork at regular intervals. The clockwork drives a counting device which registers up to 10,000 hours in 1/10 hours. The fractions of an hour are displayed in red. When the total of 10,000 hours has been reached, the counter is automatically reset to zero. Below the counter is a small rotating disc which can be seen through a small window and shows immediately whether the meter is working or not. The instrument weighs 19 oz and measures 2¼in in diameter by 3¼in deep. It can either be screw-mounted by means of brackets, or flush-mounted in instrument panels or dashboards by means of a U-piece.

British Patent Specifications

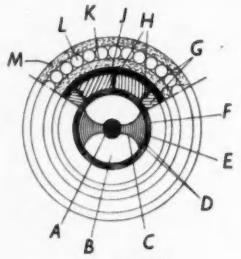
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ELECTRICAL ENGINEERING

725,533. October 19, 1953.—AN ELECTRICAL DEEP-SEA CABLE, Felten and Guilleaume Carlswerk Aktiengesellschaft, Köln-Mülheim, Germany.

Deep-sea cables have to be very strong with respect to the outer pressure. A deep-sea cable constructed according to the invention, as shown in the drawing, did not show any kind of damage during pressure tests, even at an outer pressure of 1200 atms. Thus the cable is so pressure resisting that it can be used for any water depths that may occur. The cable shows also an astonishing resiliency. Over an inner conductor *A*, for instance, of copper, lies air space insulation *B*, the supporting structure of which in this case is constituted by two distance maintaining strands *C* helically wound around the inner conductor. Each one of the strands *C* consists of a number of stretched superposed bands *D* of polystyrol, the widths of the bands increasing from inside to the outside. The air space insulation is closed by a polystyrol band *E*, which is wound to form a closure. An outer conductor *F*, which in this case is constituted by a number of flat copper wires stranded



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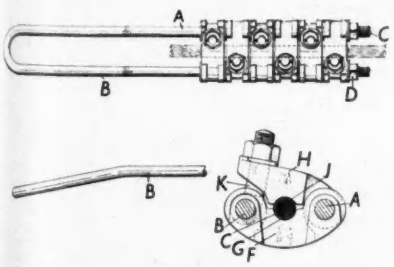
together, is mounted on it. On the cable core thus built up the pressure protecting armouring is stranded, the same consisting of laterally grooved flat steel wires *G*, in which groove wires *H* of aluminium are inserted. *J* is a seamless lead sheathing which is provided over the pressure protecting armouring *G* and *H*. Over the lead sheathing *J* there is mounted a cushioning layer *K* of jute or the like, a tension resisting armouring *L* of stranded steel wires, and a further layer *M* of asphalted jute serving as a protection against corrosion.—*March* 2, 1955.

729,268. June 18, 1953.—CLAMPING DEVICE FOR A CABLE, British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2. (*Inventor: Peter McKenna.*)

In the clamping device shown in the drawing six identical clamping units are slidably mounted on two rods *A* and *B* forming the parallel sides of a U-bolt and each clamping unit grips a portion of a cable *C*. One end of each rod is threaded to receive a nut *D* which acts as an adjustable stop against which the first clamping unit bears when the cable is tensioned by a load applied from the other end. The clamping unit, as shown in the lower view, is of the two-jaw type. It has two parallel bores, through which pass the two rods *A* and *B*, one on each side of a cable gripping jaw *G*. The member *H* has one bore only, through which passes the rod *A*, and a cable gripping



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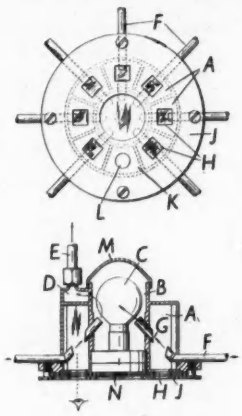
jaw *J*. The rod *B* also passes through the eye of an eye-bolt *K* housed in the member *F*. The shank of the eye-bolt passes through the member *H* so that the two jaws can be clamped together on to the cable by screwing the nut on to the eye-bolt against a flat surface of the member *H*. To reduce the bending load on the member *H* the shank of the eye-bolt is offset with respect to the eye in the direction of the rod *A* about which the part *H* pivots.—*May* 4, 1955.

MEASURING INSTRUMENTS

729,140. April 4, 1952.—SMOKE INDICATORS, The Pyrene Company, Ltd., Great West Road, Brentford, Middlesex. (*Inventors: Reginald William James Cockram and Neil Sullivan.*)

As will be seen from the drawing, the indicator comprises seven chambers *A* arranged round a central



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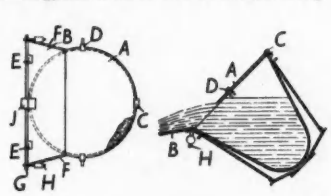
lamp housing *B* containing an electric bulb *C*. Air is continuously extracted from the housing *B* through a side connection *D* and a pipe *E*. As a result air from various compartments of a ship or aircraft is drawn along pipes *F*, one of which corresponds to each chamber *A*. The final part of each pipe *F* is directed towards the centre of the bulb, and where this part of the pipe traverses the chamber it is cut away at *G*. In this way the air from the compartment is drawn across the chamber and lies in a beam of light from the bulb. The cut-away part *G* lies in the field of an observation window *H* in a front plate *J*. When the air being drawn through a particular chamber contains smoke in suspension, then light from the bulb is scattered through the corresponding window and can be seen by an observer. When the air is clear no light can be seen, and the inside of the chamber *A* is painted dull black to ensure this. A chamber *K* at the bottom of the indicator contains loosely packed glass wool, which is illuminated by the bulb and diffuses light through a window *L* to indicate that the bulb is alight. The strength of the beams is increased by a reflector *M*. The bulb need only be lit when an observer is looking at the windows, and is supplied through a switch which can be closed by pressing a central button *N*. This button is covered by a thin sheet of rubber, which excludes atmospheric dust from the interior of the indicator.—*May* 4, 1955.

METALLURGY

729,961. January 9, 1953.—POURING MOLTEN SLAG ON A FOAMING BED, The Hüttenwerk Rheinhausen Aktiengesellschaft, Rheinhausen, Niederrhein, Germany.

The invention relates to apparatus for rapidly pouring in a wide stream a fiery, molten slag, such as blast furnace slag, on to a foaming bed having apertures or nozzles in its bottom for the passage of a foaming agent into the slag. The ladle, as shown in the drawing, has a lid *A* and *B* divided along a line



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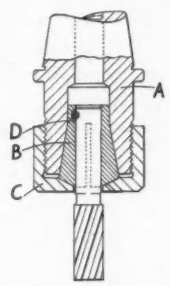
parallel to the tipping axis. The larger portion *A* of the lid is at the side remote from the discharge side and remains attached to the ladle during pouring. To facilitate filling of the ladle it is, however, hinged at *C* to the ladle and retained in position by hooks *D*. The smaller portion *B* of the lid is of trapezium form and projects beyond the edge of the ladle at both sides of the point of discharge. The projecting portions of the lid portion are connected by hinges *E* to a collar *F* fitted to the edge of the ladle. The pivotal axis *G* of the lid portion *B* carries at each end a lever *H* fitted with a counterweight. During tipping of the ladle the stationary lid portion *A* remains closed, and the lid portion *B* also remains closed until the force exerted by the weights is overcome by the slag in the ladle. As soon as the lid portion *B* is opened by this counterforce (see the drawing) the contents of the ladle are discharged rapidly on to the foaming bed. The lid portion *B* is then supported, e.g. by an abutment *J* in a position as shown in the drawing, in which the outflowing slag can spread over the pouring lip constituted by the collar *F* and the hinged portion *B* of the lip and so flow in a wide stream on to the pouring bed over the long overflow edge of the lid portion. It is advantageous so to relate the size on the lid *A* to the pressure exerted externally on the lid *B* that during the pouring the upper part of the slag is held back for as long as possible by the lid *A* and solid constituents which have formed in the slag remain behind in the ladle.—*May* 11, 1955.

MACHINE TOOLS

729,051. July 31, 1952.—CHUCKS FOR MACHINE TOOLS, Alfred Cleaver, 88, Edward Road, Balsall Heath, Birmingham, 12.

Referring to the drawing, in a chuck of the usual type *A*, is mounted a tapered split collet *B* having a parallel bore. The lower end of the collet has an inclined face engaged by a cap *C*, which screws on to the chuck to force the tapered collet into the body and thereby grip the shank of the tool in the chuck. To ensure that there will be no slip between the tool shank and the chuck, a slot *D* is formed at right angles to the axis of the bore of the collet. This slot is in alignment with and communicates with the tapered hole in the chuck body. The shank of the tool has a recess complementary to the tapered hole in the chuck body. A tapered pin inserted in the hole prevents slip between the tool shank and the chuck and also axial movement.—*May* 4, 1955.

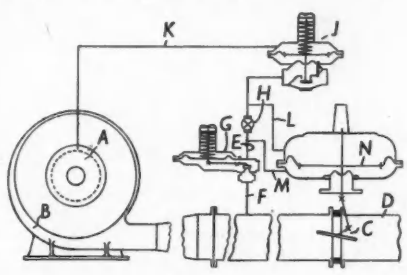


No. 729,051

FURNACES

729,563. September 17, 1952.—FORCED DRAUGHT SYSTEMS IN FURNACES, E. E. Jeavons and Co., Ltd., of Lower Church Lane, Tipton, Staffs. (*Inventor: Malcolm William Jeavons.*)

The invention relates to forced draught systems in furnaces such as cupolas or blast furnaces and provides means for governing the supply of air to the furnace at a substantially constant volume rate. How the invention is used to control the air flow to a cupola furnace is shown in the drawing. The orifice plate *A* is placed at the intake of a centrifugal fan *B* and a diaphragm-operated butterfly valve *C* controls the delivery of air to a pipe *D* supplying the wind belt. Air for the servo line *E* is supplied from the delivery of the fan through pipe *F* and a pilot



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governor *G* which maintains a substantially constant pressure at the inlet of a needle valve *H* forming a restriction. The outlet to atmosphere of the servo line *E* is controlled by a diaphragm-operated spring-loaded control valve *J*. The underside of the diaphragm of the control valve is open to atmospheric pressure while the upper side has the pressure on the downstream side of the orifice *A* applied to it by the pipe connection *K*. The greater the flow through the orifice the lower the pressure applied through the pipe *K*. In operation if the air flow exceeds the desired value for which the spring loading of the valve *J* has been set, the control valve begins to close, reducing the flow through the servo line restriction *H* and the differential pressure across it. This differential pressure is applied by pipes *L* and *M* to a large diaphragm *N* connected to the main valve *C* and tends to close the butterfly valve until the rate of flow has been brought back to the desired value. The

reverse action takes place upon a reduction in air flow below the desired value. The rate of flow by volume to be maintained by the controller may readily be varied by altering the spring loading of the control valve *K*. The invention has several advantages. Only a single pipe connection *L* is needed between the orifice *A* and control valve *K*. There is very little flow through this connection which may therefore be of small bore. The control valve *K* and the other parts of the controller may be at a considerable distance from the orifice *A*. The servo system is energised by the pressure of the air being controlled.—*May* 11, 1955.

RAILWAY ENGINEERING

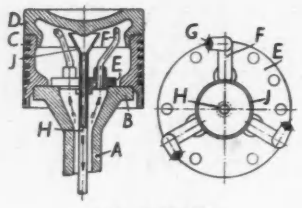
729,579. October 23, 1952.—HARDENING RAIL HEADS, The Hüttenwerk Rheinhausen Aktiengesellschaft, Rheinhausen Niederrhein, Germany.

According to the invention the rails supplied from the rolling mill are first cooled sufficiently to permit of examination of their surface. Those suitable for hardening are then picked out and may be preheated, if desired, preferably to a temperature of 400–500 deg. Cent. Subsequently, the surface layers of the rail heads of the selected rails are heated to the hardening temperature and quenched. The rail feet are then heated sufficiently for the heat flowing from the foot to the head through the web to temper the surface layer of the rail head. Preheating of the rails has the known purpose of providing a more gradual transition from the structure of the hardened zone into that of the unhardened portion of the rail. For this purpose preheating to a temperature of 400–500 deg. Cent. has been found sufficient. The following is an example of how the invention may be carried into effect: Flat-bottomed rails, weighing 49 kg per metre and made of steel containing 0·45 per cent carbon, were taken from the rolling mill and cooled to room temperature. Their surfaces were then inspected. Selected rails which were free from surface defects were preheated for two minutes in a furnace to 460 deg. Cent. The surface layer of the rail head of each rail was then heated for a short time to 820 deg. Cent. The rails were then quenched by spraying with water and the rail feet were heated for four minutes to 375 deg. Cent. After a final cooling in the atmosphere the treated rails were straight.—*May* 11, 1955.

INTERNAL COMBUSTION ENGINES

729,624. May 19, 1953.—LIQUID-COOLED PISTONS, Aktieselskabet Burmeister and Wain's Maskin- og Skibsbyggeri, No. 4, Strandgade, Copenhagen, Denmark. (*Inventor: Ove Petersen.*)

In the oil-cooled pistons of internal combustion engines there is a tendency for the cooling oil to become superheated so that a layer of coke forms on the walls of the cooling space, causing the heat transmission to be reduced considerably. The purpose of the invention is to remedy this drawback with cooling by means of a liquid sensitive to superheating. In the drawing, *A* is the upper end of a piston rod which at its top carries a flange *B* on



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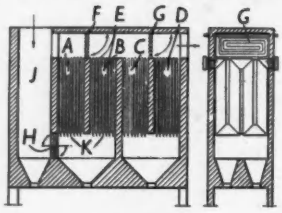
which the piston proper, comprising a body *C* and a top portion *D* secured to it, is bolted. The piston rod is hollow and closed above by a flange *E* in which three tubes *F* are inserted with their upper ends bent sideways and directed slightly obliquely upwards to form discharge nozzles *G*. The flange *E* carries a central tube *H* which is led down into the hollow piston rod and at its top has a mouth in the form of a small funnel *J* lying close to the centre of the inside of the end surface of the top portion *D*. Cooling oil is, in the usual manner, led in through the piston rod *A* and further on through the tubes *F*, the discharge nozzles *G* of which discharge the oil in the form of jets to the inner side wall of the cooling space formed in the piston almost at the transition between the side wall and the end surface. The oil in the cooling space is in this way kept in rotation around the axis of the piston, and the walls are kept well cooled and free from deposits. The oil supplied gradually flows in towards the centre to be led away through the outlet tube *H*, and during this inward motion the velocity of rotation of the oil increases very strongly and imparts an effective sweeping to the central part of the inside of the piston top where the risk of excessive heating and coke formation is usually the greatest. Modified designs are also given in the specification.—*May* 11, 1955.

STEAM GENERATORS

729,909. December 30, 1953.—FORCED RECIRCULATION WASTE HEAT STEAM GENERATORS, Heinrich Vorkauf, partner of La Mont Kessel Herpen and Co., Kommanditgesellschaft, Hildesheimer Strasse 195, Hanover, Germany.

The invention relates to improvements in steam generators utilising the waste heat from gases which escape from chemical or metallurgical furnaces and are dust-laden or corrosive. In the waste heat boiler shown in the drawing, there are four vertical passes, *A*, *B*, *C* and *D*. The heating surfaces *E* fitted in these passes are constructed as tube panels. Dampers *F* and *G* are arranged above the gas passes and a



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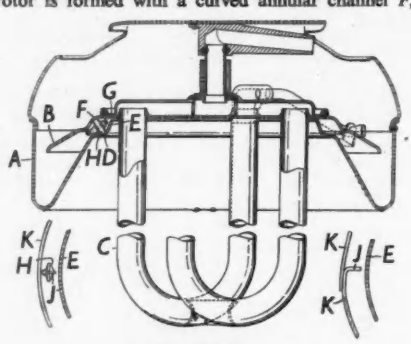
damper *H* is arranged below them. When working with high gas temperatures it is preferable to construct the dampers of water-cooled tubes. To prevent heat losses, the working medium of the boiler may be used as a cooling agent. An empty pass *J* is provided in addition to the four boiler passes. When the dampers are closed, the gases flow through the four passes in succession. If the damper *H* is opened, pass *A* is shut off almost entirely from the gas circuit. Passes *A* and *B* can be shut off by opening the damper *F*, and passes *C* and *D* by opening the damper *G*. These possibilities of by-passing permit of a very flexible working of the waste heat boiler. One of the boiler passes may also be constructed as a superheater pass. In this case, the temperature of the superheated steam may also be regulated by adjusting the dampers as required. The heating surfaces *E*, which are constructed as closed tube panels, rest on a lower grate support *K*. Walls formed of tubes arranged side by side may replace the brick dividing walls between the various passes. A modified design is also shown in the specification.—*May* 11, 1955.

BEARINGS AND SUPPORTS

729,832. October 17, 1952.—ROLLER BEARINGS, R. A. Lister and Co., Ltd., Dursley, Gloucestershire. (*Inventor: Theo Sherwen.*)

The invention relates to roller bearings for use in inclined concave races formed on complementary members of apparatus which are required to have rotational freedom about a substantially vertical axis. The churn cooler shown in the drawing comprises a stator *A* to fit on the head of a churn and a rotor *B*, including cooling loops *C*, rotated by a cold water jet expelled within the stator. The lower face of the stator *A* terminates in a corrugation *D* having a substantially vertical portion *E* which forms the lower race for the roller bearing. The lower face of the rotor is formed with a curved annular channel *F*,



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the underside of the channel of which forms the upper race for the roller bearing. Three or more rollers *H* are spaced within the races and supported on inclined stub axles *J* of stiff wire, all of which are attached to a common supporting ring *K*. The rollers, which may be made of nylon, or other suitable plastic, have radiused rolling surfaces and have the general shape of spinning tops. In one form, as shown in the lower, left-hand view, the stub axles *J* are attached at the correct incline to the plane of the ring *K* by soldering, brazing or the like. In another form (shown in the right-hand) the stub axles *J* and supporting ring *K* are made from curved lengths of wire, one end of each length being bent to form an axle and all the lengths being brazed or welded together to form the ring. In operation the rotor rolls freely on the series of rollers whose inclined axes of rotation ensure that it remains centred in the stator.—*May* 11, 1955.

Catalogues

MATTHEWS AND YATES, Ltd., Swinton, Manchester.—New catalogues of electric propeller fans and unit heaters.

WODEN TRANSFORMER COMPANY, Ltd., Moxley Road, Bilston, Staffs.—Brochure of Woden power transformers.

DELORO STELLITE, Ltd., Highlands Road, Shirley, Birmingham.—"Production Milling by Deloro Stellite."

RAIL TRACTION SUPPLIES, Ltd., 61, Catherine Place, London, S.W.1.—Booklet describing the Hadfield precision power reverser.

DAVEY PAXMAN AND CO., Ltd., Traction Department, Colchester, Essex.—Booklet illustrating and describing "YH" diesel engines for rail traction.

G.W.B. FURNACES, Ltd., P.O. Box No. 4, Dibdale Works, Dudley, Worcs.—Leaflet covering "Powermaster" packaged automatic boilers suitable for firing on oil or gas.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

CEMENT AND CONCRETE ASSOCIATION

Tues., June 14th.—PRESTRESSED CONCRETE DEVELOPMENT GROUP: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, "Prestressed Concrete Structures in Germany with Concentrated Tendons," F. Leonhardt, 6 p.m.

ELECTRIC RAILWAY SOCIETY

Sat., June 4th.—Visit to Stonebridge Park Power Station and Repair Sheds. Stonebridge Park Station, 1.40 p.m.

INCORPORATED PLANT ENGINEERS

Tues., June 7th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, a talk on Work Study by a member of the British Productivity Council, 7 p.m.
——MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, Open Meeting, 7.15 p.m.
Thurs., June 9th.—N.E. BRANCH: Roadway House, Oxford Street, Newcastle upon Tyne, "Steam for Process," L. G. Northcroft, 7 p.m.
Thurs., June 16th.—MERSEYSIDE AND N. WALES BRANCH: Royal Institution, Colquitt Street, Liverpool, "Liquid Fuel Firing," S. S. Whitehead, 7.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Sun. to Sat., June 19th to 25th.—LONDON: Twenty-second International Foundry Congress.

INSTITUTE OF INDUSTRIAL ADMINISTRATION

Wed., June 8th, 15th and 22nd.—LONDON BRANCH: Fyvie Hall, The Polytechnic, Regent Street, London, W.1, Higher Management Lectures, "The Practice of General Management," 6.30 p.m.

INSTITUTE OF PETROLEUM

Thurs., June 30th.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, Four papers outlining, "The Story of the Co-ordinating Research Council," by M. K. McLeod, T. B. Rendel, E. S. Macpherson and W. J. Sweeney, 3.30 and 5.30 p.m.

INSTITUTE OF PHYSICS

Thurs., June 23rd.—NON-DESTRUCTIVE TESTING GROUP: Royal Technical College, Glasgow, Annual General Meeting, 9 a.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., June 9th.—YORKSHIRE CENTRE: Afternoon visit to Hepworth and Grandage, Ltd., St. John's Works, Bradford, Yorkshire.
Thurs., June 16th.—LONDON CENTRE: Day visit to the Metropolitan Police Motor Driving School, Hendon, London, N.W.9.

INSTITUTION OF CIVIL ENGINEERS

Tues., June 7th.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon. to Sat., June 6th to 11th.—Summer Meeting in Scotland.

INSTITUTION OF MINING ENGINEERS

Wed. to Fri., June 15th to 17th.—Summer Meeting in Edinburgh.

INSTITUTION OF MINING AND METALLURGY

Thurs., June 16th.—General Meeting, Geographical Society, Burlington House, Piccadilly, London, W.1, "Application of Plastic Igniter Cord to Blasting Operations in Metalliferous Mines," R. Haslam, R. D. J. Owens and J. Hancock, "Concealed Lead-zinc Fields in England," G. A. Schmellmann, 5 p.m.

INSTITUTION OF NAVAL ARCHITECTS

Thurs., June 9th.—Weir Lecture Hall, 10, Upper Belgrave Street, London, S.W.1, "The Influence of Dimensions on the Behaviour of Partial Superstructure," W. Muckle, "The Strength of Corrugated Plating for Ships' Bulkheads," J. B. Caldwell, 4.45 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., June 6th.—12, Great George Street, London, S.W.1, Annual General Meeting, 5 p.m.
Fri. and Sat., June 10th and 11th.—Annual Conference of Mining Surveyor Members: Caledonian Hotel, Edinburgh, Friday: "The Scottish, English and Welsh Coalfields: Geological Similarities and Differences," G. H. Mitchell, 10.30 a.m.—Saturday: "Survey Problems Arising out of Colliery Reconstruction," Clifford Beevers, 10.30 a.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, June 3rd.—Café Royal, Regent Street, London, W.1, Annual General Meeting, 6.15 p.m., Annual Dinner, 7.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., June 8th.—MANCHESTER BRANCH: Engineer's Club, Albert Square, Manchester, Annual General Meeting and Film Show, 6.45 p.m.